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THE car-builders generally seem to be looking forward to a busy season, and several large contracts have already been announced. The heavy crops in the West will make a demand for an increased number of freight cars, while the roads leading to Chicago are already making preparations for the great increase of traffic which they expect from the Exposition in that city, so that passenger and freight car business both are benefited.

SUBSTANTIAL progress is now being made with the buildings of the Columbian Exposition at Chicago. Not very much has been done toward the proper representation of railroads there, and some hard work will have to be done within the next year to secure it.

THE fighting ships of the Navy, as distinguished from the cruisers, are making slow but steady progress toward completion. The engines of the armored cruiser *Maine* are now ready for the vessel, and her completion next year is a possibility if the armor plates are furnished in time. Work on the engines of the *Texas* has been slightly delayed, but the vessel itself is making excellent progress at Norfolk. She will probably not be launched until next spring, but much of the work which has been done on the *Maine* since her launch will be done on the *Texas* in the yard, so that no time will be lost. The armored cruiser *New York*, at the Cramp yards in Philadelphia, is so far advanced that she will be launched before the close of the year, and she will be ready for service at about the same time as the *Maine*.

THE navigation of the air has heretofore been hardly considered a practical question by most men, chiefly from the reason that those who have attempted it have generally been persons without sufficient theoretical or practical knowledge to meet the conditions involved. It has now been undertaken, however, by another class of men, who are thoroughly equipped for dealing with the problems involved, and experiments conducted by such high authorities as Professor Langley, of the Smithsonian Institution, and Mr. Chanute, President of the American Society of Civil Engineers, promise some valuable results. Professor Langley is especially firm in the belief that the time is not far distant when some practicable device for traveling through the air will be secured, and he is doing his best to aid in such a result.

In another column we give the first part of an account of the Progress of Aerial Navigation, by Mr. Chanute; in these papers he will describe the theoretical conditions involved, give a historical account of the attempts which have heretofore been made, and a description of the experiments now in progress.

THE New York Central & Hudson River Company is making arrangements to replace the signals at present in use between the Grand Central Station and Mott Haven by an entirely new system, which will be supplied by the Johnson Signal Company, and will be as complete as possible. The need of such a change has been apparent for some time, the present one being insufficient. It is true that there are a large number of trains to be handled there, as the traffic of the Hudson River and Harlem Divisions and of the New Haven road is concentrated upon the five miles between the Grand Central and Harlem Bridge; but the company has the advantage of four tracks, except for the very short distance across the bridge, and there are practically no freight trains to interfere with the passenger business. With a better signal system it is probable that the delays, of which there is now much complaint, will be done away with, leaving only those which are unavoidable at present, at least so long as the Harlem drawbridge remains.

THE Baltimore & Ohio Company is making considerable expenditures on the improvement of its terminal facilities. New yards are being provided for the better handling and distribution of freight, and an expensive belt or connecting road is under construction through Baltimore. When these are completed the road will be better placed than ever before to dispose of a large freight business. From the returns made public, it appears that these new facilities are needed, for the traffic of the road has shown a large and steady gain for several months past.

SOME reference has heretofore been made to the terminal improvements which the Pennsylvania Railroad is making in Jersey City. The new passenger station there and the elevated line through the city are now approaching completion, and the company will soon have the best passenger station in or about New York. It is somewhat singular that the largest city in the country has been notable heretofore for the shabbiness and inadequate size of its railroad stations, but something has really been done at last to remove that reproach. The Erie, the New Jersey Central, and the Pennsylvania now have stations which are fairly well fitted for their business, and of sufficient size, though not much can be said of their architectural beauty; and if the New York Central can hardly say the same, it is because the business of the Grand Central Station has increased more rapidly than enlargements could be made to provide for its accommodation.

THE instances cited above might be increased in number, but they are sufficient to indicate that the heaviest railroad expenditures of the present year have been made not in building new railroads, but in terminal improve-

ments and facilities for handling business on existing roads. The growth of cities and towns has been so rapid during the last 10 or 15 years that improvements have been forced on the railroads and the cities alike. In many cases these have been deferred too long, so that the increased value of property has made them more costly and difficult of execution than they would have been if undertaken sooner; but this is a trouble that always has existed, and probably always will exist as long as man's "hindsight is better than his foresight," as they say in New England.

ANOTHER new line to the Pacific will before long be completed by the Great Northern Company, the successor to the St. Paul, Minneapolis & Manitoba. This line will depend for its prosperity on the growth of the new States along the northern frontier, and for through business will be a formidable competitor of both the Northern Pacific and the Canadian Pacific.

THE death of Mr. John H. B. Latrobe, of Baltimore, removes one of the very few remaining men whose personal experience reached back to the beginning of railroads in this country. Mr. Latrobe had been connected with the Baltimore & Ohio Railroad in various capacities all through his active life; he was the son of the great engineer whose genius may almost be said to have created that road, and he was the last survivor of those who accompanied Peter Cooper on the trial trip of his little locomotive, on the success of which so many future possibilities depended. We of the present generation find it hard to realize how small and apparently insignificant was the commencement of our railroads; but Mr. Latrobe had seen it all with his own eyes, and had taken an active and useful part in the small beginning and the later growth.

THE Interstate Commerce Commission has suffered a serious loss in the retirement of its head, Judge Cooley, and the recent death of Mr. Bragg. Judge Cooley commanded general respect from his knowledge of the law, his ability and the judicial temper of his mind; he came to the Commission with a high reputation from his service on the bench, and has given his knowledge and experience to the difficult questions which have arisen under the law. Commissioner Bragg had had previous experience on a State commission, and was one of the most active, faithful, and hard-working members of the Board. It will be no easy matter to fill the vacancies properly, and it is to be hoped that considerations of fitness alone will govern the President in selecting the new commissioners.

THE breaking up of the Squadron of Evolution has begun by the detaching of several of the vessels composing it for service in various stations. The squadron has apparently served its purpose, and the new ships will probably be sent off one by one. Their services are urgently needed to replace the older ships, which are now nearly worn out, and must give place to their modern successors.

THE Canadian Pacific has accomplished a notable feat in landing the Japanese mails in London within 20 days of the time of their starting from Yokohama. This was done by fast passages across both the Pacific and Atlantic oceans, and a quick rail trip from Vancouver to New York. Heretofore no attempt at speed has been made by the steamers crossing the Pacific; but the new competition may bring their standard up nearer to that of the Atlantic lines than it has been.

WITH this record, which our own lines will doubtless try to cut down, and with the Great Siberian Railroad actually in progress, giving promise of a through line from St. Petersburg to Vladivostok in a few years, the time may not be far distant when a man may start from New York for a little trip around the world with a reasonable expectation of reaching his home again within the month.

FAST time is reported on land as well as by water, and recently a train on the Philadelphia & Reading Railroad, in a run, the particulars of which are given elsewhere with those of another fast run on the New York Central, made a mile in 39.8 seconds, or at the rate of 90.45 miles an hour. This, it is claimed, is the fastest railroad time ever made.

STATE ownership and State construction of railroads are not made more attractive by the corruption lately brought to public notice by the parliamentary investigation in Canada. Our own methods of railroad building have their defects, but at least they do not involve the grave public scandals which, we fear, could not be avoided where great and expensive public works are carried on by a government conducted by political parties, and largely through politicians, as ours must be. Canada is learning a hard lesson, which ought to serve as a warning to other countries.

UNIFORM REPORTS OF LOCOMOTIVE PERFORMANCE.

ONE of the subjects which has been selected for consideration by a committee of the Master Mechanics' Association, and to be reported on next year, is the one which forms the title of this article. Any one interested in the performance of locomotives, who takes the trouble to study the reports made by different railroad companies, will find that they differ so widely from each other that it is difficult to make any comparisons which are conclusive with reference to the relative performance on different roads. There is no common agreement regarding the data which are reported, and in many cases essential facts are omitted altogether. As heretofore stated in these pages, some companies issue reports printed on the backs of postal-cards in which only the most meager data are given. Other companies, as the Illinois Central, issue reports on a number of sheets which are 35 × 19 in. in size, on which the most minute statistics are given with reference to each engine on the line.

A student of the subject will soon find that the reports of some roads are almost useless, by reason of important omissions, whereas those of other lines are confusing on account of the great mass of figures, from which it is difficult to draw any deductions. In this, as in all other fields of human endeavor, it is important to discriminate between those things which are essential and effective in accomplishing the end aimed at and those which serve no useful purpose. A study of any considerable number of these performance sheets, as they are called, will reveal to the student many defects and omissions, and their ambiguity is in many cases very vexatious.

A little consideration of the object of making such reports will indicate the data which they should contain. Their chief purpose undoubtedly is to enable comparisons to be made of the performance of locomotives on the same or on different roads, and thus to ascertain their relative efficiency and economy.

Thus the "chief end" of a locomotive—to quote the Catechism—is to haul trains, and the more hauling it does the better it fulfills its "final cause." That is, the more miles it runs and, in many cases, the more cars it pulls, the better it fulfills its purpose, and the greater its value or efficiency. In other words, a locomotive which will run on an average 3,000 miles per month is worth more to a railroad company than one which will run only 2,000, and for some kinds of traffic a machine which will pull 30 freight cars is much more useful than one which will pull only 20. Therefore to compare what may be called the *serviceability* of locomotives on the same line, or on different lines, or in different countries we should know how many miles they run, per day, per month or per year. There should be no ambiguity about this mileage—that is, it should be definitely known whether the mileage is counted only by the distance between terminals, or whether any extra allowance is made for running the distance from the engine-house to the station, or *vice versâ*; for switching or for any other reason. There should be no difference in the method of keeping the mileage on different lines, and the committee appointed to report on this subject should recommend some definite method of keeping the mileage of different classes of trains, and of switching and construction engines, etc.

A good deal of difference prevails, too, in the matter of the division of this mileage. Only a portion of the reports which are published give the number of the engines owned by the companies. In some cases the total mileage is divided by the number of engines which are in a serviceable condition—that is, which are not undergoing repairs. In others all the engines owned are included. For purposes of comparison it seems desirable that each company should report the total number of locomotives owned which are not condemned or leased to other lines, and also the average number in the shop undergoing repairs or held in reserve. This will make it possible to give the average mileage of all engines owned—which is the safest basis of comparison—and also the average mileage of those in service. Obviously it is a merit of the management of the mechanical department to keep the engines in such a condition as to get the maximum mileage out of them, and the fewer there are in the shop the greater the mileage that can be made. If an account was kept of every day that each engine is in the shop, and at the end of the month the aggregate number of days was divided by 30, it would give the average number undergoing repairs during the month, or at the end of the year. By dividing by 365 it would give the average for the year. Probably such figures as these would be a revelation to many general managers if compared with similar data from other roads.

It may at any rate be confidently said that all locomotive reports should give the mileage of locomotives based upon some common method of making it up, and also the number of engines owned by the company which are not condemned.

For the same, and also for another reason, the train loads should be reported. It hardly needs to be said that in some kinds of traffic the larger the loads hauled the greater the useful service performed. Besides this reason, it is impossible to make any comparisons of fuel consumption which can be relied on without knowing the loads hauled. In many of the reports before us no account whatever is kept of the train loads. On other lines the average number of cars in all trains is given, and on still others the average number of passenger and freight cars is reported separately.

The ordinary postal-card report gives the total number of miles run by all locomotives. This makes any comparison between the service of passenger or freight engines impossible. Many roads, however, now report separately the total mileage of passenger, freight, switching and construction engines. If in the enumeration of the engines owned they would divide them into the number employed in each of their different classes of service, it would enable comparisons to be made of the service performed by the locomotives in each of these kinds of traffic. The report of the Pennsylvania lines west of Pittsburgh gives the miles run by freight engines "loaded" and "empty," and also the average and the maximum mileage of engines in each class of service. This is admirable for purposes of comparison.

The expenses of locomotive service are usually divided into cost of fuel, oil, waste, repairs, wages of engineers and firemen, cleaning and attendance, fuel and water stations. Some considerable differences exist in the method of dividing these accounts. The fuel consumption is reported most frequently by the average number of miles run to a ton of coal. In the Erie Railroad report the number of pounds of coal used per mile in passenger, ballast, switching and freight service, and also the amount consumed per passenger and per freight car per mile, is reported. This is the most satisfactory form of report with reference to fuel consumption that we know of, especially as the average number of cars per train for both passenger and freight trains is also reported. To report the number of pounds of coal consumed per mile seems very much more satisfactory than to give the number of miles run per ton, as the latter always involves the doubt whether a ton of 2,000 or 2,240 lbs. is meant.

In giving car mileage two empty freight cars are usually rated as one loaded, but on some lines three empties are rated as two loaded ones, and on the Missouri Pacific five empties are assumed to be equal to three loads. It is desirable, of course, that there should be some uniform practice in this respect, although it is possible that, owing to peculiarities of traffic, one rating might be nearer correct on one road than another rating would be somewhere else.

In regard to reporting the consumption of waste, lubricating oil, tallow and illuminating oil a great diversity of practice prevails. In some reports it is all included under the general head of "stores." In others waste, lubricating and illuminating oils are reported separately. In the report of the St. Louis & San Francisco Railroad the consumption of engine, valve, illuminating and lubricating oils and waste are each given separately. It seems as though it would be sufficient to report lubricating and illuminating oils and waste separately, giving the number of miles run to a pint of oil and a pound of waste.

The cost of repairs is very generally reported as so much per mile run, although on some of the Pennsylvania lines it is given as so much per 100 miles run. It is not

always clear, however, what is included under the heading of repairs. The whole cost of building new engines to replace old ones on some roads is charged to repairs. On others only that part of the cost which equals the original value of the engine replaced is charged to repairs. Some uniform practice is very desirable, which the committee having the subject under consideration should recommend.

The wages of engineers and firemen are very generally charged at so much per mile run, although in some cases the cost of cleaning and attendance is included. A better plan seems to be to keep these expenses separate.

In reporting the cost of locomotive service the price at which fuel is charged is usually given, although some curious ambiguities are practised, such as charging coal at some nominal price quite different from its actual cost. The total cost of locomotive service is in some cases carried out and given at so much per mile run. In some reports the cost per car mile is also given. All such data would be very much more satisfactory if the cost for different classes of traffic, such as passenger, freight, switching, and construction, was given separately, per engine and per car mile. This would make comparisons and analyses of accounts possible, which without such division cannot be made.

It seems very certain that if locomotive reports gave more complete data concerning the cost of motive power service, that they would indicate where economy is possible, whereas with the reports as made at present managers of roads are now in great darkness.

A CORRECTION.

In the September JOURNAL, page 426, there was published an article on Electric Lighting by Water Power, condensed from a paper read by C. T. Ryland, Jr., before the California Electrical Society. This was accompanied by illustrations of the Dodd sigmoidal water-wheel (figs. 1 and 3) and by a cut (fig. 2) purporting to show the curve of efficiency obtained from a wheel of that pattern running an electric light plant at the Geyser Hotel, in Sonoma County, Cal.

Information of a reliable character has since been furnished to us to the effect that no such test was ever made on the Dodd wheel. A test was made, but it was on a Pelton wheel, which was then running the electric light station at the Geysers, where the experiments were conducted. The efficiency curve was, in fact, that of the Pelton wheel.

We make this correction as a matter of justice to the Pelton Water Wheel Company, whose wheel is entitled to all the credit for high efficiency in the test.

The paper in question was sent to us as coming from a responsible source and having been read before a reputable public association. The condensation was made by Mr. Ryland, and there was no apparent reason to doubt the statements made. It now appears that there was an imposition practised in changing the name of the wheel, which is not at all creditable to those who may be responsible.

In this connection it may be noted that there is at present much interest felt in methods of utilizing water powers heretofore neglected. This will be increased by the remarkable results recently obtained in Germany in the transmission of power long distances by electricity.

NEW PUBLICATIONS.

REPORT OF THE PROCEEDINGS OF THE 24TH ANNUAL CONVENTION OF THE AMERICAN RAILROAD MASTER MECHANICS' ASSOCIATION. *Held at Cape May, N. J., June 6, 7, and 8, 1891.* Edited by Angus Sinclair, Secretary. The Association, New York.

This report makes its appearance in good season this year, and shows signs of careful editing in its general arrangement and in the complete index appended to it. As the convention was one of average interest, with no special features, the report follows the same course. The discussions on Air Brake Standards and on Compound Locomotives will perhaps receive the most attention. As usual, the report is published in very neat style.

HANDY LIST OF BOOKS ON MINES AND MINING. *A Reference Catalogue.* Compiled by H. E. Haferkorn. H. E. Haferkorn, Milwaukee, Wis.

This is Part IV. of Mr. Haferkorn's "Handy Lists" of technical literature. Like the preceding numbers, it is intended to give as complete a list as possible of all books in the special department to which it refers. Its preparation must have required a great amount of work, and it will be of much service to students, engineers and others interested.

NATIONAL CAR AND LOCOMOTIVE BUILDER SUPPLEMENT. *August*, 1891. John N. Reynolds, New York.

This *Supplement* makes its yearly appearance as usual, but is larger than ever before, the present number having 124 pages in all. It contains much useful information, having lists of locomotive builders, car builders, car wheel, axle and spring makers, rail mills and others useful for reference. There are also lists of street railroads and their officers, and of the railroads of South America, with their officers.

The number of advertisements in the *Supplement* is so great that it may almost be considered a directory of manufacturers of railroad supplies. It is increased this year by many street-car builders and manufacturers of electrical appliances.

A SHORT MANUAL OF ANALYTICAL CHEMISTRY, QUALITATIVE AND QUANTITATIVE—INORGANIC AND ORGANIC. By John Muter. *First American from the Fourth English Edition.* Edited by Dr. Claude C. Hamilton. P. Blakiston, Son & Company, Philadelphia.

Mr. Muter's reputation as an analytical chemist would lead to the acceptance of his book as high authority. It is, of course, strictly technical in its nature, and is intended as a book of reference and for advanced students; those whose knowledge of chemistry is elementary would find it very difficult reading. The writer's aim has evidently been to condense the information as much as possible, and to give the student an account of the latest and most approved methods of analysis in a small space.

The editor of the American edition has made some changes in classification and arrangement, and has introduced the name of each chemical formula, where that formula appears in the book for the first time. Some additions have been made also, and the changes are generally improvements.

ANNUAL REPORT OF THE CHIEF OF THE BUREAU OF STEAM ENGINEERING, NAVY DEPARTMENT, FOR THE YEAR 1890. Engineer-in-Chief George W. Melville, Chief of Bureau. Washington; Government Printing Office.

Like the report for the preceding year, this report covers a period of hard work. During the year the Bureau was called upon to design machinery for battle-ships 1, 2 and 3; armored cruiser No. 2; protected cruiser No. 5; cruiser No. 12, and

the Ammen ram, all large and important ships. This work had to be done in addition to supervising work on the vessels already begun, the repairs and routine work at the navy yards and a large amount of experimental and testing work, especially in connection with tubulous boilers. These represent a large amount of hard work.

Engineer-in-Chief Melville again calls attention to a matter which is just now troubling nearly all the navies of the world, the insufficiency of the engineer force. The traditions of the naval force have been almost everywhere, it seems, strong enough to prevent the increase of the engineer force in number and rank in proportion to the increase of its real importance, and until this is overcome the trouble will continue.

SAFE BUILDING. *A Treatise Giving Practical and Theoretical Rules and Formulæ used in the Construction of Buildings.* By Louis de Coppet Berg. Ticknor & Company, Boston; price, $5.

Perhaps a better title for this book would be "Architectural Engineering," for it is really a manual of engineering as applied to the construction of buildings of all classes. The author's object has been to teach, so far as can be done by books, the knowledge necessary to erect buildings which shall be safe, and sufficiently strong for the purposes for which they are to be used.

The various chapters include Strength of Materials; Foundations; Cellar and Retaining Walls; Walls and Piers; Arches; Floor Beams and Girders; Graphical Analysis of Transverse Strains. There are a number of tables giving strength of beams, strength of materials, etc., and a large number of formulas. As a general rule, the diagram, the formula on which the table is based and the table are brought as close together as possible—a much better practice than the common one of placing the tables by themselves at the end of the book. The formulas generally are worked out so that they can be followed and understood by any one whose knowledge of mathematics extends to arithmetic, algebra and plane geometry.

Mr. Berg has evidently tried to condense the matter in hand as much as possible, and to use no more space in explanation than was absolutely required. Considering the extent of the subject this was necessary, perhaps, but in some places it has been carried almost too far, and a little more extended explanation might have been of service. It is a book which requires careful study and not merely reading.

As a manual of the engineering of architecture it must be extremely useful to architects; it is an excellent manual and book of reference for the engineer also, especially the railroad engineer, who is so often called upon to design and construct buildings. He will here find the general rules, with which he is of course familiar, reduced to practise and specially applied to the case of buildings in a way which is very convenient, and will probably save him much time and work. There are, of course, many things which are found in other treatises, but the special applications are new and put in a form where they are at hand and ready for use in any case which may be under consideration.

ANCIENT AND MODERN LIGHT-HOUSES. By Major D. P. Heap, Corps of Engineers, United States Army. Ticknor & Company, Boston; price, $5.

Light-houses are a sign of civilization, and can hardly be expected to exist until a nation advances far enough to have a commerce of considerable importance. They have existed since very ancient times, however, as is known by undoubted testimony, although very little is known of their construction. In the Mediterranean there were some famous structures, such as the great Pharos of Alexandria, but nothing now remains of them. In modern times, as commerce has extended, the number of light-houses has very greatly increased, and now they are found all over the world.

There are numerous classes of light-houses and beacons. Shore lights are not generally difficult of construction; but there are many on exposed rocks and shoals where the very best skill of the architect and the engineer has been required to plan structures which can resist the force of the ocean, and to devise means for building them. How difficult such work may sometimes be is shown by the fact that the light-house on Minot's Ledge, off the Massachusetts coast, was under construction five years; in one year—1857—only 130 hours' work could be done, so uncertain was the sea, while a single storm in two days almost entirely destroyed two years' work. The loss of the great caisson prepared for the foundation of the Diamond Shoal Light, off Cape Hatteras, is a recent instance of the dangers and uncertainties of such work.

Major Heap, who has had a long experience as an engineer in light-house work, has made a very interesting volume of 220 pages, in which he describes generally the different classes of light-houses and their design, and then gives accounts of a number of noted buildings, such as the Eddystone, the Bell Rock and the Skerryvore lights in English waters; the Minot's Ledge, the Spectacle Rock, the Tillamook, the Rothersand and others on our own coasts. Full descriptions of these typical structures are given, with accounts of the methods followed in building them and the ways in which the difficulties met were overcome. Apart from their general interest these are worth study, if only to see the resources at the command of an engineer who has to meet and control the ocean before he can complete his work.

Besides a number of smaller engravings in the text, the book has 32 large plates, which are admirably executed; indeed, it is quite refreshing to read a book where so little fault can be found with the illustrations.

THE YEAR'S NAVAL PROGRESS: ANNUAL OF THE OFFICE OF NAVAL INTELLIGENCE, JULY, 1891. *General Information Series. No. X: Information from Abroad.* Prepared by the Office of Naval Intelligence, Navy Department. Government Printing Office, Washington.

The present volume of the Annual of the Office of Naval Intelligence retains the title of last year's issue, and, like that number, is not devoted to any special subject, but rather to a general review of the naval progress of the year in various countries. The topics included in it cover a wide range, as will be seen by the titles of the various chapters, which are: I. Notes on Ships and Torpedo Boats; II. Notes on Machinery; III. Notes on Ordnance; IV. Electricity on Shipboard; V. The Naval Manœuvers of 1890; VI. The Armor Question in 1891; VII. The Coast Defense Systems of Europe; VIII. Service High Explosives; IX. The Torpedo Vessel: a History of its Development; X. The System of Promotion in European Navies; XI. Some Standard Books on Professional Subjects.

EXPERIMENTS IN AERODYNAMICS. By S. P. Langley. *Smithsonian Contributions to Knowledge.* Smithsonian Institution, Washington, D. C.

This is, perhaps, the most important single publication which has ever been printed on the subject of aerial navigation. It proves facts that have long been suspected by students of the subject, and explodes theories that have been the pets of some scientific men for many years. Professor Langley not only shows that mechanical flight is possible, but that it is possible by the use of mechanical means already in our possession and with many of which we are familiar.

Flight by the use of buoyant gas bags or by vibrating wings is entirely omitted in the discussion, and no experiments have been made on such apparatus; but they have been entirely confined to aerial propelling screws and to rectangular planes moved through the air under various conditions of velocity, angle of impact, and superposition, Professor Langley evi-

dently believing that if flight is accomplished by man, it will be after the manner in which soaring birds navigate the air on wings which are apparently motionless.

To prove the truth of this impression, a whirling table 60 ft. in diameter was constructed at the Allegheny City Observatory, Allegheny City, Pa., about four years ago, and numerous experiments were made whenever the weather permitted. At the edge of the whirling table were placed the screws and planes which were experimented upon.

The planes were always rectangular, and were forced through the air sometimes with the long edge, sometimes with the short edge in advance. They were sometimes horizontal, sometimes inclined with the forward edge highest, and the uplift and the resistance to forward motion, due to the pressure of the air on the under side of the plane, were automatically registered by devices of great delicacy and accuracy.

One of the most important conclusions from these experiments is that the inertia of the air plays a very effective part in the flight of birds—much more effective than is usually supposed. If a horizontal plane in rapid horizontal translation be allowed to fall through the air, its time of fall will be much greater than if it fell vertically; and this retardation, due to the horizontal translation, is so marked that Professor Langley concludes that any formula which would correctly indicate it would also show that if the plane were given an infinite horizontal velocity, its time of fall would also be infinite. The reason for this phenomenon is that the air, having inertia, requires time to be put in motion and leave the path of the plane. This leads up to the very important principle which nature observes in the construction of the best flying animals—viz., that the rectangular dimensions of the supporting surfaces should differ as widely as may be, and that the direction of motion should be in the direction of the least dimension. Thus the long-winged sailing birds act upon a greater mass of air in the same time than those which have short wings, and there is therefore less air put in motion under the wing, there is less "slip," and there is less power required.

The point upon which Professor Langley lays the greatest stress, and which he evidently believes to be the most important one indicated in the Memoir, is that the power required for horizontal flight will decrease when the velocity increases, the weight remaining the same. This statement is so insufficiently qualified as to be quite misleading to those who have given the subject of aerial navigation but little or no attention. Professor Langley, throughout the whole Memoir, has ignored the resistance which the air will oppose to the motion through it of the body of any aerial craft, and of the edges of those portions which form the supporting surfaces. It was well for him to do so; but it would have been much better had he frequently and explicitly so stated, especially in connection with the conclusion referred to, and which he considers important enough to repeat several times and to italicize.

The casual, or even the fairly close reader would certainly infer from Professor Langley's Memoir that that gentleman desired to convey the impression that the limit of possible speed was entirely indeterminate, and that perhaps 400 or 500 miles an hour might be expected, while as a matter of fact a few calculations show that under the most favorable circumstances the limit will be reached at perhaps a quarter of that speed. Although the power required to overcome gravity will undoubtedly decrease somewhat when the velocity increases, the power required to overcome the resistance of the air on other than the supporting surfaces will increase as the cube of the velocity, weight being unchanged.

The apparatus used in the experiments was evidently designed with great ingenuity and constructed with great care. The author has not attempted to deduce formulæ, but has indicated some conclusions which may be drawn from the experiments, and most of the mathematical work is correctly done.

The preface states that most of the financial means for conducting the experiments were furnished by the late William Thaw, of Pittsburgh, and the Memoir has been referred to a commission of which Professors Simon Newcomb, Henry A. Rowland, and Cleveland Abbé are members.

TRADE CATALOGUES.

Catalogue E, Presses, Dies, etc.; made by the Ferracute Machine Company, Bridgeton, N. J.

The extent to which press and die work has been carried by manufacturers is shown by the fact that this company makes regularly and carries in its catalogues 150 different kinds of presses, this including only the regular styles, and not special presses made to order. The present catalogue includes only a part of these, other catalogues being published by the company; but it covers a wide range, from light foot presses weighing only 250 lbs., up to power presses weighing 9,000 lbs. and intended for the heaviest class of work. The Ferracute Company probably has a greater variety of work to do in this line than any other establishment, and its catalogues are worth consulting.

Goulds' Triplex Power Pumps for Mill Service. The Goulds Manufacturing Company, Seneca Falls, N. Y.

Goulds' Triplex Electrical Pumps. The Goulds Manufacturing Company, Seneca Falls, N. Y.

The object of the first of these pamphlets is to show the advantages obtained by the use of the Goulds triplex pump in mills, for filling tanks, for boiler feeding, for paper machines, and in other places where a smooth-running, steady and reliable pump is needed. The applications are fully illustrated by diagrams, and the pamphlet is so neatly printed and mounted as to make it very attractive to the eye.

The second is intended to describe and illustrate the use of the pump with an electric motor, which may be applied in many places where it is not convenient to use a steam-pump or steam-engine. This catalogue is illustrated and printed very handsomely also.

What We Manufacture. The Cincinnati Corrugating Company, Piqua, O.

How to Make Money out of Inventions; an Adviser for Patentees: by August Schemmel. The C. A. Rohde Company, Milwaukee, Wis.

BOOKS RECEIVED.

A Treatise on Wooden Trestle Bridges, According to the Present Practice on American Railroads. By Wolcott C. Foster. New York; John Wiley & Sons. This book is received too late for review in the present number.

Poor's Directory of Railway Officials and Manual of American Street Railroads: 1891. New York; H. V. & H. W. Poor.

Selected Papers of the Institution of Civil Engineers. London, England; published by the Institution. The present installment includes several important papers.

Progressive Examinations of Locomotive Engineers and Firemen. By John A. Hill. New York; published by the Author; price, 50 cents.

Reports of the Consuls of the United States to the Department of State: No. 129, *June*, 1891. Washington; Government Printing Office.

The Statistical Year-Book of Canada for 1890. Compiled by Sydney D. Roper. Ottawa, Canada; published by the Department of Agriculture. Sixth year of issue.

The Mechanical Errors in the Common Theory of Flexure. By R. H. Cousins, C.E. Houston, Texas.; published by the Author.

Transactions of the Liverpool Engineering Society: Volume XII. Seventeenth Session. Edited by J. H. T. Turner, Honorary Secretary. Liverpool, England; published by the Society.

Annali della Societa degli Ingegneri e degli Architetti Italiani, 1891. *Part III.* Rome, Italy; published by the Society.

Cornell University, Agricultural Experiment Station: Bulletins 29, *July,* 1891, *and* 30, *August,* 1891. Ithaca, N. Y.; published by the University.

TECHNICAL SCHOOLS.

THE University of Wisconsin at Madison has made important changes in its Technical Department, which are perhaps best explained by the following extract from its announcement:

There have been added three entirely new chairs: a professorship of Railroad Engineering, a professorship of Electrical Engineering and a professorship of Machine Design, and to these there have been called men of exceptional training and ability. Besides these additions, the work of the existing chairs has been modified and developed so as to give a better division of labor and superior efficiency. The professorship of Mechanical Engineering becomes centralized upon steam engineering as its leading subject. The theoretical and scientific treatment of electricity and magnetism heretofore falling under the professorship of Physics has been developed into a professorship of Electricity and Magnetism in connection with mathematical physics, and will have for its functions the fundamental scientific treatment of those subjects, while the practical side will be treated by an experienced expert under the professorship of electrical engineering. A professorship of Bridge and Hydraulic engineering has been developed from the chair of Civil Engineering and the latter title dropped, because, in the progress of engineering science, it has become too broad and indefinite. The assistant professorship of Pure and Applied Mechanics has been advanced into a full professorship with the slightly modified title of Theoretical and Applied Mechanics. The chair of Mechanical Practice undergoes no change except an enlargement of facilities. An instructorship in Engineering has been added.

The Pratt Institute in Brooklyn, N. Y., has made many improvements in its Scientific Department in the way of more extended courses, and in its Trade Schools in increasing the range of instruction and the facilities for practical work.

Purdue University at Lafayette, Ind., has completed a new engineering laboratory, a building 50 × 110 ft., with a boiler-room 25 × 40 ft. In these buildings are a Babcock & Wilcox boiler; a Harris-Corliss triple-expansion engine, and a Schenectady locomotive, the latter mounted so as to allow its performances to be tested. There are also steam pumps, testing machines, and apparatus for hydraulic work in considerable variety.

ABOUT BOOKS AND PERIODICALS.

THE article in SCRIBNER'S MAGAZINE for October on the New Lake in the Desert, by Major J. W. Powell, is written by one who speaks with authority from his intimate knowledge of the natural conditions. The number contains several other readable papers, and is fully up to the standard of this well-known magazine.

Among the articles in the POPULAR SCIENCE MONTHLY for October are Mr. Durfee's on the Manufacture of Steel; Professor Dolbear's on Metamorphoses in Education; Professor Patrick's on the Rivalry of the Higher Senses, and Mr. Carroll D. Wright's on Lessons from the Census. The last named is the first of a series which cannot fail to be valuable.

In HARPER'S WEEKLY for September 9 there is a very interesting illustrated article on the Alaskan Boundary Survey. The same number has a full-page cut of the new Grand Central Station in Chicago, and an account of the work done by the Columbian Exhibition Commissioners abroad.

In the ARENA for September there are several notable articles, perhaps the most striking being on Inter-Migration, by Dr. Schindler; on the Austrian Postal Bank System, by Sylvester Baxter; on Constitutional Government in Japan, by Kuma Oishi, and on Un-American Tendencies, by Dr. Martyn.

Mr. Montgomery Schuyler's Glimpses of American Architecture close in HARPER'S MAGAZINE for October with his impressions of characteristic buildings in St. Paul and Minneapolis. Other articles are on Cairo, on Plantagenet London, on the Art Students' League of New York, and a number of lighter articles, making excellent reading.

The COMPASS for September has articles describing a new slope-stake setter and universal slope indicator, designed by Mr. William Coxe. Other articles are on Verniers Proportionally Divided, the Plain Transit, and on Speedy Calculators. The continuation of the article on Series of Numbers, which was begun in the first number of this paper, contains some useful hints as to practical application.

The September number of the JOURNAL of the New England Water-Works Association contains the report of the proceedings of the tenth annual convention, which was held at Hartford in June. In this report there are several interesting discussions besides all the papers which were presented at the Convention.

The latest number of the PROCEEDINGS of the Engineers' Club of Philadelphia gives the annual address of President Spangler. Among the papers in this number are Rail Joints, by G. W. Creighton; Continuous Rails, by R. T. Gleaves; Lobnitz System of Moving Rocks under Water, by E. S. Crawley, and a very interesting illustrated paper on Topographical Surveying, by Harvey Linton.

The SCHOOL OF MINES QUARTERLY for July has an article on Brick Pavements, by Werner Boecklin, and one on Graphic Field Notes, by Bailey Willis. The rest of the number is chiefly devoted to articles from the chemical and metallurgical sections of the school.

In the OVERLAND MONTHLY for September are articles on Trout Fishing in California, on Pitcairn's Island, and on some Pioneer Experiences, besides a variety of excellent sketches and stories.

The JOURNAL of the American Society of Naval Engineers for August has articles on the Orvis System for Steam Boilers, by Chief Engineer Isherwood; on Indicator Tests, by Assistant Engineer F. H. Conant; the Servé Ribbed Boiler Tube, by Passed Assistant Engineer G. Willits, and a number of others of interest. Nearly all the articles are illustrated.

The JOURNAL of the Military Service Institution for September continues General Tidball's paper on Artillery in the Rebellion. Other articles are on Field Exercises, by Major Babcock; on the Northern Volunteers, by Colonel Livermore; Military Service Reform, by Colonel Anderson, and the Organization of Artillery Defense, by Captain Chester. There is also the usual variety of translations and items of interest to military readers, many of them being also interesting to civilians.

A new paper which has lately made its appearance is RAILWAY LAW AND LEGISLATION, which is published in Washington under the conduct of W. P. Cannaday and G. B. West. Its

object is expressed in its title, and it may be made a very useful journal under proper management.

The announcement has been made of the consolidation of the Chicago RAILWAY AGE and the NORTHWESTERN RAILROADER, heretofore published at St. Paul. Mr. Harry P. Robinson, of the *Northwestern Railroader*, will be at the head of the new concern, and Mr. H. R. Hobart, who has been connected with the *Age* from its first beginning, will remain as Editor. We hope that the consolidated paper will combine the many excellent features which have heretofore marked both papers, and we cordially wish our old-new contemporary the prosperity which it deserves.

The latest number of the PROCEEDINGS of the United States Naval Institute contains four long and elaborate papers, the first being on Explosives and Ordnance Material, by Mr. S. H. Emmens; the second on the Stability of Unarmored Ships and the Effect of Water-Line Damage, by Charles Hemje; the third, the most purely technical of the number, is on the Naval Reserve and Naval Militia, by Lieutenant J. C. Soley, while the fourth is on the Final Improvements of the Steam Engines, by Professor Thurston.

In OUTING for September there is a variety of travel and sport sufficient to suit all readers. The number has some excellent illustrations. The military article for the month is on the Massachusetts Volunteer Militia, and concludes the account of the military establishment of that State.

SOME CURRENT NOTES.

A NEW line between New York and Boston has been opened by the Long Island and the New York & New England Companies. The train runs from Brooklyn to Oyster Bay over the Long Island Railroad, and is then ferried across the Sound on the transfer steamer *Cape Charles* to Wilson's Point. From there to Hawleyville the route is over the Danbury & Norwalk Railroad, and from Hawleyville to Boston over the New York & New England. The time made at present is about eight hours, and only one train is run—a night train composed of sleeping cars.

THE Grand Trunk Tunnel under the St. Clair River, between Detroit and Port Huron, of which a description has already been given, was formerly opened for traffic September 19. The trains are run through the tunnel by special engines built for the service; they are of sufficient size to handle trains over the heavy grades in the approaches, and burn coke in order to avoid smoke.

THE traffic through the Sault Ste. Marie Canal in August was larger than ever before in the history of the canal for one month. The total number of vessels passed through was 1,720, of which 1,229 were steamers, 434 sailing vessels, and 57 rafts and unregistered boats. These vessels carried through 1,545,607 tons of freight and 8,099 passengers. It is evident that the lake ship-owners are trying to make the best of what remains of the season of navigation.

THE long-distance transmission plant which has been built in connection with the Electrical Exhibition at Frankfort, in Germany, was completed early in September and put into operation. This plant was, to a certain extent, experimental, as its builders undertook to transmit power by electricity over a much greater distance than had heretofore been attempted. The power is derived from the waterfall at Lauffen, in Switzerland, and the plant is intended to transmit 300 H.P. from that place to Frankfort, a distance of 120 miles. A special pole line was built for the purpose, part of it being in the rough mountain country, where many difficulties were met with in completing the line. The latest news from Frankfort is that power is now being transmitted regularly without difficulty, and that the dynamos at Lauffen are operating 1,000 electric lights in Frankfort very successfully. Experiments with this important line are to be continued for some time, and should they prove completely successful, the field for the utilization of power and transmission by electricity will be greatly widened.

THE Philadelphia & Reading Company now claims that the best railroad time on record has been made on its road. The run was made August 27, and was an experimental one, made to see how great a speed could be attained. The train was drawn by Engine No. 206, which has 20 × 24-in. cylinders, 68-in. drivers, and a Wootten boiler. The train consisted of two ordinary passenger cars and the President's special car, and the run was on the Bound Brook Division. Time was taken on 12 miles, from Noble to Langhorne, the total distance being run in 8 minutes 42.2 seconds. The time for each mile is given as follows:

Miles.	Seconds.	Miles.	Seconds.	Miles.	Seconds.
1.	45.0	5.	46.2	9.	40.0
2.	42.6	6.	42.6	10.	39.8
3.	44.6	7.	42.4	11.	47.8
4.	47.2	8.	42.0	12.	42.0

The train, therefore, ran the 12 miles at an average speed of a mile in 43.5 seconds, or at the rate of 82.53 miles an hour, while the best mile was made at the rate of 90.45 miles an hour.

WHILE the quickest short run on record is apparently noted above, a New York Central & Hudson River train has made the quickest long distance run. Like the other, it was an experimental run, made for the purpose of deciding what time could be made by a through train between New York and Buffalo. The train consisted of two drawing-room cars and General Superintendent Voorhees' private car; the total weight of the three being 259,600 lbs. The engine which drew the train from New York to Albany was No. 870, a Schenectady engine having 19 × 24-in. cylinders and 78-in. drivers; the boiler is 58 in. in diameter and the fire-box 96 × 40⅞ in. The engine weighed, at starting, 60 tons and the tender 40 tons, making the total weight of the train 230 tons. From Albany to Syracuse the train was drawn by Engine No. 876, and from Syracuse to Buffalo by No. 862, both of these locomotives being the same as No. 870, except that their driving-wheels are 69 in. instead of 78 in. in diameter.

The total time for the 436½ miles from New York to East Buffalo, without deducting stops, was 439¾ minutes—7 hours, 19¾ minutes. The train left the Grand Central Station in New York at 7:30 15 A.M., and reached East Buffalo at 2:50 P.M. From East Buffalo to the Buffalo station 8¼ minutes were required.

The run of 436½ miles was thus made at an average speed of 59.53 miles an hour, without allowance for stops. Three stops were made in all—at Albany, to change engines, 3 minutes 28 seconds; at Syracuse, to change engines, 2 minutes 30 seconds; at Fairport, to cool a hot box, 7 minutes 50 seconds. The total time lost was thus 13:48 minutes, leaving the actual running time 426 minutes. The time over the three divisions of the road, deducting stops, was as follows:

	Miles.	Minutes.	Av. speed miles per hour.
New York—Albany	143	140	61.29
Albany—Syracuse	147⅜	146	60.55
Syracuse—E. Buffalo	146	140	62.57
Total	436⅜	426	61.88

The total time consumed from station to station, 440 miles, without making allowance for the stops or for the comparatively slow time from East Buffalo to Buffalo station, was 448 minutes—an average of 58.93 miles an hour.

It is understood that an approach to this extraordinary time is to be put into practice. Having shown the possibility of making the run to Buffalo in 7½ hours or so, the company will put on a fast train which will make the trip every day in a much shorter time than is now done.

THE new ore docks of the Escanaba, Iron Mountain & Western Railroad near Escanaba, Mich., are said to be the largest in the world. Their construction occupied about eight months, and cost $281,605. The material used included 6,534 piles, 6,434,331 ft. lumber, 81,329 lbs. cast iron, 981,062 lbs. wrought iron and 733,584 lbs. steel. The dock itself is 1,427 ft. long; the rails on top are 52 ft. above water level, while below are 232 pockets having a total storage capacity of 45,000 tons of iron ore. The approach to the dock is by timber trestle on pile foundations; this trestle is 2,091 ft. long and from 20 ft. to 52 ft. in height; there is also a Howe-truss span of 126 ft. over the Chicago & Northwestern tracks. This dock was built under the direction of Chief Engineer G. M. Willis, with Assistant Engineer E. C. Hollidge in charge of construction.

AN elevated railroad is now under construction in Liverpool for passenger traffic. It will be, when completed, about 6¾ miles long, running along the water front, where the heavy traffic to and from the docks almost prohibits passenger transit by stage or horse car. The line has two tracks of standard gauge, has stations at convenient intervals, and the cars will be run by electric motors. It is carried on steel plate girders spaced 25 ft. apart; the normal span is 50 ft., but at some street crossings and dock entrances this is increased. The minimum clear headway above the street is 16 ft. At the Stanley Dock entrance a draw-bridge had to be provided. The roadway is composed of steel arch-plates, riveted together and resting at the ends on the bottom flanges of the main girders. The rails will be laid on longitudinal wooden sleepers. The columns carrying the main girders consist of two steel channel-bars riveted to two steel plates, forming a square box column. They are set in cast-iron sockets resting on a masonry bed.

THE fastest time on record in the waters around New York has been made by the little steam yacht *Norwood*, which has attained the rate of 28 miles an hour, running from the Narrows to Sandy Hook. The *Norwood* was modeled and built by C. D. Mosher, of Amesbury, Mass.; she is 63 ft. 2½ in. long and 7 ft. 6 in. beam. The screw is 36 in. in diameter, and is driven by a triple-expansion engine which has worked up to 400 H.P., with 150 lbs. of steam. The boiler is of the Thornycroft pattern.

ACTING upon a message from the Governor and a communication from the Railroad Commissioner, Mr. Charles R. Whitman, the Legislature of Michigan in June last adopted concurrent resolutions requesting Congress "to enact such legislation as may be necessary to ensure the adoption on all railroads in the United States of automatic couplers and train brakes; or such other legislation as may be necessary to insure the making up and running of trains without compelling railroad employés to enter between or on the tops of cars while the same are in motion."

Similar action, it is said, will be urged upon the legislatures of other States as soon as possible.

A NEW CHAIR CAR.

THE accompanying engravings show one of several fine chair-cars recently built by the St. Charles Car Company, at St. Charles, Mo., for the Jacksonville Southeastern Line, of which Mr. William J. Hemphill is Superintendent of Motive Power. These cars were built for the through line between Chicago and St. Louis formed by the Jacksonville Southeastern and the Atchison, Topeka & Santa Fé. Fig. 1 is a side elevation; fig. 2 is a plan, showing arrangement of the seats, closets, etc.; fig. 3 is from a photograph, showing the general appearance of the car; fig. 4 is from a photograph showing the inside of the car and the Scarritt-Forney seats used.

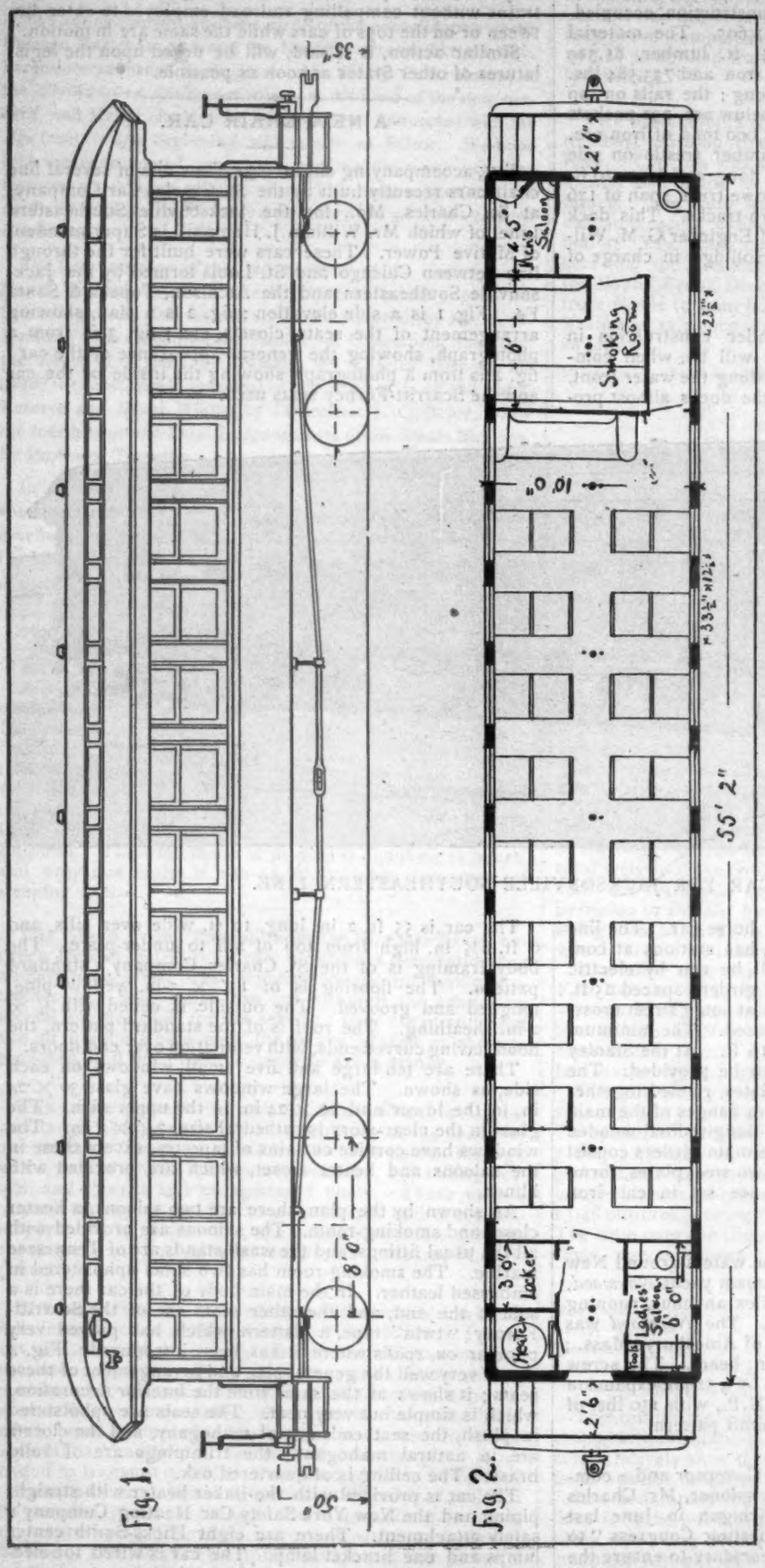
CHAIR CAR FOR JACKSONVILLE SOUTHEASTERN LINE.

The car is 55 ft. 2 in. long, 10 ft. wide over sills, and 6 ft. 8½ in. high from top of sill to under-plate. The body framing is of the St. Charles Company's standard pattern. The flooring is of 1¼ × 3-in. yellow pine, tongued and grooved. The outside is ceiled with ¼ × 2-in. sheathing. The roof is of the standard pattern, the hood having curved ends, with ventilation over end doors.

There are ten large and five small windows on each side, as shown. The large windows have glass 30 × 24 in. in the lower and 20 × 24 in. in the upper sash. The glass in the clear-story is cathedral size, 7¼ × 7 in. The windows have cornice curtains of tapestry, except those in the saloons and heater closet, which are provided with blinds.

As shown by the plan, there are two saloons, a heater closet and smoking-room. The saloons are provided with all the usual fittings, and the wash-stands are of Tennessee marble. The smoking-room has two sofas upholstered in embossed leather. In the main body of the car there is a sofa at the end, and the other seats are of the Scarritt-Forney "twin" type, a pattern which has proved very popular on roads where it has been introduced. Fig. 4 shows very well the general plan and arrangement of these seats; it shows at the same time the interior decoration, which is simple but very neat. The seats are upholstered in plush, the seat ends are of mahogany, and the closets are in natural mahogany; the trimmings are of solid brass. The ceiling is of quartered oak.

The car is provided with the Baker heater with straight piping and the New York Safety Car Heating Company's safety attachment. There are eight Hicks-Smith center lamps and one bracket lamp. The car is wired for electric lights.



CHAIR CAR FOR JACKSONVILLE SOUTHEASTERN LINE.

BUILT BY THE ST. CHARLES CAR COMPANY, ST. CHARLES, MO.

The platforms are the standard Miller type, with wrought-iron drawbars. The car is fitted with the Boyden brake, with Hodge's system of brake levers. The brake-shoes are the Christie head on the "National" hollow brake beam.

The trucks are four-wheeled trucks of the St. Charles Company's standard pattern, with wheels spaced 8 ft. apart. The pedestals, journal boxes and journals are the M. C. B. standard pattern. The axles are M. C. B. standard, of iron, and the wheels are 33-in., double plate, weighing 600 lbs. each. The bolster springs are quintuple elliptic 3 × $\frac{11}{32}$ × 36 in., and the equalizer springs are three-coil round-bar spiral 8 × 10 in.

The vestibules are covered with oil-cloth and the body of the car with Wilton carpet. The minor fittings include 18 umbrella holders and six card tables. Large mirrors are placed on the bulkhead partition, and the toilet rooms are very neatly fitted up.

The seating capacity is 35 in the body of the car and 7 in the smoking-room, making 42 in all. It is an excellent example of the latest practice in passenger car construction.

THE SINKING OF THE "BLANCO ENCALADA."

(From London *Engineering*.)

WE have received from a correspondent copies of the official reports of the sinking of the *Encalada*, written by Captain Goni, the commander of the vessel, and by the senior officer in charge of the attacking torpedo gunboats the *Almirante Lynch* and *Almirante Cordell*. The details are very meager, but they have the advantage of being written by those who are acquainted with the subject of naval warfare, and are, therefore, more satisfactory than the newspaper reports hitherto received, and which were apparently written more with a view to supplying a sensational column of descriptive writing rather than a true narrative of events.

Captain Goni's report is very brief. He states that his vessel was attacked by the *Lynch* and *Condell*, and that six out of the seven torpedoes they fired struck the ship. That is a remarkable average, and further details of damage done would be of great interest. As the vessel is sunk in shallow water, her bridge appearing above the surface, and as there was a diver on the spot, it is to be hoped we may subsequently get some particulars on this head. Captain Goni simply states that "the torpedo catchers were hotly cannonaded by the *Blanco* before she sank;" and that about half of the crew was lost, among them being all the engineers.

INTERIOR OF CHAIR CAR, JACKSONVILLE SOUTHEASTERN LINE.

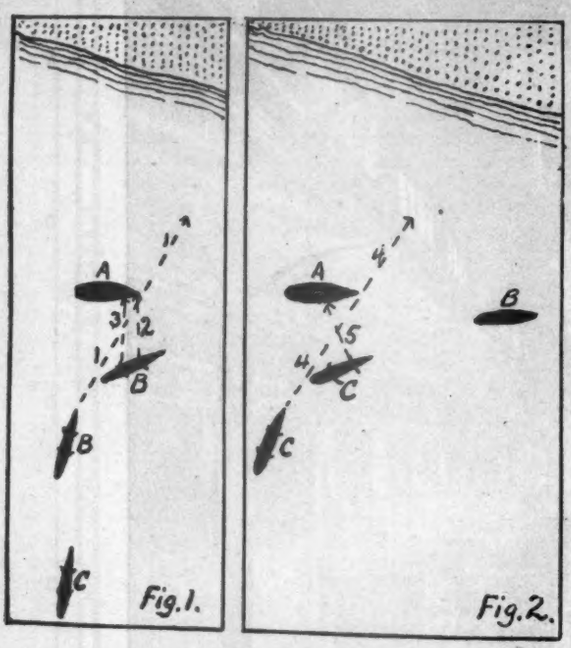
The part of the report of Captain Moraga, the commander of the torpedo vessels, which refers to the action is a little more detailed, and is as follows:

A little before 4 A.M. (April 23) I entered Caldera Bay, and as soon as the light of the moon enabled me to do so, I made out the position of the revolutionary vessels. Meanwhile the *Lynch* followed in my wake at a distance of about 50 meters. At half-speed I pointed the bow at the *Blanco* or the *Cochrane*; I was not able then to see which of the two I had ahead. There was another vessel at the side which I took to be the *Huascar*. At a distance of approximately 100 meters I fired the bow torpedo, which passed just ahead of the iron-clad, almost touching it, and which, I think, struck a vessel lying near. Immediately after this first shot I sheered off to the starboard, and at a distance of about 60 meters Lieutenant Vargas dexterously fired the first port torpedo, which must have struck the bows of the attacked vessel. At the same time I ordered Lieutenant Rivera to fire from the same side the after torpedo. Between the sending off of the second and third torpedo the iron-clad opened a rapid and persistent fire upon my vessel, making use of her mitrailleuses, rapid-firing guns and rifles. After firing the first torpedo I went ahead at full speed. The iron-clad's fire continued to be directed against my vessel, as she did not observe that the *Lynch* was performing the same manœuvre as the *Condell*. The *Lynch* approached to within a short distance, when she fired her bow torpedo, which missed. Steering off to star-

board, the *Lynch* fired her second torpedo, which struck the *Blanco* about amidships, and two minutes afterward the revolutionary vessel foundered. Seven minutes more or less elapsed between the firing of the first torpedo from the *Condell* and the last from the *Lynch*.

The accompanying sketch shows, in fig. 1, the *Condell's* and in fig. 2 the *Lynch's* attack. In both *A* is the *Blanco Encalada*; *B* the *Condell*; *C* the *Lynch*. The dotted lines show the course of each torpedo fired, and are numbered in order, 1 showing the course of the first torpedo, 2 the second, and so on.

It will be seen from this account that five torpedoes were fired, not seven, as stated by Captain Goni, and that three of them hit the mark. A good deal has been said in naval circles here about the *Encalada* not having her tor-



pedo-nets rigged; and a good deal of censure has been passed upon Captain Goni on this account. As a matter of fact, we believe the vessel was not supplied with nets—at least none were fitted when she was overhauled and rearmed at Elswick a few years ago; and it is improbable that this means of defense has been since supplied. We doubt, however, if any defense of that nature could have saved the ship. The attack was well planned and well executed, the *Lynch* well seconding her leader's efforts—always a matter of great importance in torpedo-boat attack. The first torpedo that hit—the second fired—would probably have so disorganized the net defense that the second would have got through to the vessel's side. If, however, both these torpedoes had expended their power on the net, there is, we think, little doubt but that the *Lynch's* torpedo would have got through; but even had that been entangled and exploded, the latter vessel had another torpedo left on the port side, while both vessels had two more torpedoes on the starboard side. Where the Congressional vessels were to blame, however, was in not sending out the vidette boats. A good system of pickets is a far more effective protection against such attacks than any amount of nets rigged out on booms. The lookout vessels need not necessarily be steam craft, although, of course, the latter are preferable, as they enable a longer line to be patrolled; but one man in a dingy with a blue light can give just as good an alarm as a steam pinnace with a dozen hands on board.

A point worth noting is the failure of both bow torpedoes. Both boats missed in the same manner—namely, the weapons going across the bows of the attacked vessels, as shown in the annexed sketch. No doubt the boats overdid a good thing and delayed too long in firing the bow weapon; or probably the helmsman got nervous and began to edge off too soon when he saw the hull of the iron-clad suddenly looming up through the dull moonlight. This is always a danger with bow torpedo fire when the tube is built into the vessel so that the weapon can only be directed by manœuvring the craft herself. For a single shot we should prefer the built-in bow gun. In that case the boat should run up end-on until well within striking distance, and having fired, sheer off only sufficiently to pass close under the bow or stern. Of course such a proceeding is extremely risky; but for a torpedo-boat to attack a well-armed ship is a matter which requires men to forget that they are likely to be shot, and the boldest course is often the safest. When it is required to fire torpedoes from training guns on deck, the manœuvre of running under the bow or stern is inadmissible, or rather undesirable, as the reduced area of target due to the end-on position of the ship attacked would lessen the chances of hitting. It may be said that the bow fire is an extra chance if not a very good one; but it must be remembered that the chances which depend on the expenditure of a Whitehead torpedo must necessarily be very few, and we think it is doubtful policy to have one of them locked up in a gun that can only be pointed by moving the whole vessel with the rudder. That, however, is a question upon which there is much to be said on both sides, and further experience may be directly opposed to that gained by the fight in Caldera Bay.

NOTES ON COMBUSTION.

By C. Chomienne, Engineer.

(*Continued from page 413.*)

THE THEORY OF SMOKE.

We know that pure carbon burning, even with an insufficient supply of air, never produces smoke. It is the same with charcoal and with coke. The hydrocarbons, on the other hand, give much smoke whenever they are burned with too small a supply of air. The experiments of M. Berthelot have proved that when we heat certain hydrocarbons to a fixed temperature, we produce a new hydrocarbon, more condensed, with a deposit of pure carbon. Let us see what takes place on a grate charged with coal.

If we assume that this grate is covered with coal half consumed, and that it contains only coke in an ignited state, it will not produce smoke, but if we throw fresh coal upon the fire we see at once black smoke rising from the mass and passing into the smoke-stack. Quickly the smoke diminishes in quantity and ends by disappearing entirely until another charge of coal is thrown upon the fire. Let us see what has been found in this case. At the moment when the coal touches the ignited surface, the hydrocarbons which it includes feel the action of a high temperature and their distillation is produced. These vapors coming into contact with the air immediately burn and consume the oxygen surrounding them. If no fresh air comes to renew the supply of oxygen a quantity of gas is formed which will be carried into the chimney in the same state in which it was when it left the grate; that is, imperfectly burned. This explains the presence of hydrocarbons in the gaseous products of combustion.

There is still another thing to take into consideration—the dissociation of gases, an admirable discovery which is due to M. Sainte Claire Deville.

When a compound gas is brought to a sufficiently high temperature the elements which compose it will separate, but if the mixture resulting from this separation is quickly cooled, we find instead of the compound gas which we had originally a simple mixture. If, on the other hand, the cooling is slow, the elements will recombine and we will have the original compound gas.

In consequence, at the moment when the hydrocarbons are disengaged and are carried to a very high temperature they become a mixture of carbon in a state of vapor

and of hydrogen. If a sufficient quantity of air is furnished the combustion will be complete; if not, it will be imperfect, and we will have the first case when the cooling is slow; but if the cooling is rapid—as may happen if the gases come in contact with the passages or with the bridge or even with a current of cool air—the carbon will appear in the form of black smoke and the hydrogen will remain free. This accounts for its presence in the gaseous products of combustion and also for that of a new quantity of hydrocarbons which are formed by what M. Deville has called a partial recomposition.

In the passages of a boiler all these phenomena are partially reproduced. When the gases touch the walls of the boiler, which are at a comparatively lower temperature, smoke is produced by the precipitation of the carbon. There also results the rapid heating of the hydrocarbons on the grate, producing the reaction shown by M. Berthelot, and the rapid cooling of the gases resulting in the reaction of M. Deville; these are the two principal causes of the formation of smoke. There is always a lack of air, which is, if not the only cause, at least a necessary cause. In spite of this, and according to careful experiments, smoke, if black and as thick as it can be even when it is produced by design and by not giving the fire-box a sufficient quantity of air, will not represent a loss of more than 1.5 per cent. If the supply of air is increased a little this loss will fall to 0.5 per cent.

As we have before stated, the composition of the gaseous products of combustion varies very greatly as the smoke is black, light colored or almost colorless. Each of these states correspond to a different degree of loss, and the blackest smoke is that which shows the most imperfect combustion. This is generally true, but it is hardly necessary to believe that in all cases the loss shown would be proportional to the color of the smoke, since it may happen that colorless gas includes carbonic oxide, which constitutes a greater loss than that resulting from black smoke.

In order to know how during a definite time—100 minutes, for example—the three conditions of the smoke are presented, M. Burnat made a series of experiments. He took the most unfavorable conditions and used an oily coal, which is certainly the fuel most apt to give rise to loss of heat by incomplete combustion. He carried the combustion of carbon to its maximum point with an insufficient quantity of air in such a way as to produce as much black smoke as possible; using 2 kg. of coal per hour per square decimeter of grate surface, and a supply of 6 cub. m. of air to 1 kilogram of coal, he found that black smoke was given out for 32 minutes; gray or light colored for 33, and colorless for 35. He then tried the reverse conditions; that is to say, he reduced the consumption to a minimum, 0.54 kg. of coal per hour per square decimeter of grate with a large supply of air, 16 cub. m. per kilogram of coal. He then found that black smoke lasted 4 minutes; gray, 27, and colorless, 69.

For his third trial he adopted the average combustion; that is to say, about 0.75 kg. per hour per square decimeter of grate, with a supply of 15 cub. m. of air per kilogram of coal. In this case he found that black smoke lasted 10 minutes; gray, 30, and colorless, 60.

M. Burnat afterward analyzed each of these kinds of smoke, with the results shown in the table below:

Component Gases.	Black Smoke.	Gray Smoke.	Colorless.
Carbonic acid	11.00	8.00	10.86
Oxygen	7.20	12.90	11.48
Carbonic oxide	1.55	0.18	0.00
Hydrogen	0.58	0.93	0.33
Nitrogen	79.67	77.99	77.33
Total volume	100.00	100.00	100.00

These analyses do not show carbon except in combination with oxygen in different proportions.

EVILS OF INCOMPLETE COMBUSTION.

It follows from this examination that the loss due to smoke under good conditions of combustion is quite insignificant. It is true that we look for smoke-consuming apparatus not only for reasons of economy, but for others connected with property, and especially with public health.

In fact it is not carbonic acid which is most noxious in smoke. It is dissipated physically in the air, while the carbonic oxide is much more dangerous. It attacks the organs of breathing, and is really a very deleterious gas. It is especially dangerous because its density is 0.97, almost equal to that of the air, and for this reason it is apt to be uniformly diffused through the atmosphere, while carbonic acid, having a density of 1.53, or one-half more than the air, is always found close to the surface of the ground.

A few thousandths of carbonic oxide in the air are sufficient to destroy the most robust health, and on an average from 1.2 up to 3 per cent. is found in smoke. From that statement one can judge the mass of poison which is daily diffused in the air. The very poisonous quality of this gas results chiefly from the property which the blood possesses of absorbing it in the same degree as it is introduced into the lungs and transforming it into a poison which acts upon the nervous centers.

As to carbonic acid it can be absorbed in a very considerable quantity without injuring animal life. There are fortunately many causes for the absorption of this gas. Water transforms it into carbonates of iron or other oxides, and plants especially absorb considerable quantities of it. There is thus an equilibrium which we cannot admire too much, and which is for us an essential condition for life.

As nature thus charges herself with the disposition in large part of the carbonic acid, it devolves upon man to prevent in every possible way the formation of carbonic oxide and to prevent also the injury which it causes in the human organism.

NECESSARY CONDITIONS OF COMPLETE COMBUSTION.

We must now study the methods of arriving at a practical result. First we should not entrust the management of boilers to unskilled persons; it is necessary to employ experienced and intelligent firemen who know how to manage their fire, charging with coal frequently and at the proper time, and regulating the draft for each case and for each kind of boiler in such a way that the loss by incomplete combustion and through the smoke-stack may be reduced to a minimum.

The automatic apparatus of M. Poindron changing the damper at the moment of firing or of arranging the fire produces an excellent result. It stops to a certain degree the abrupt supply of cold air under the boiler or upon the tube plate, and accordingly those coolings and contractions which are very injurious.

The manner in which the fireman works has a very great influence on the work of a boiler. The employment of poor firemen results in a consumption of fuel varying frequently from 25 to 50 per cent. more than a good fireman would require to vaporize the same quantity of water; and moreover the boiler will be sometimes overworked, which may occasion serious accidents.

The layer of fuel on a grate should never be less than 0.06 m., nor more than 0.16 m. in thickness according to the nature of the coal employed, the size of the lumps and the draft. With a very strong draft it may perhaps go as far as 0.20 m. in thickness.

If the layer of fuel is too thin and the fireman not very attentive, at points on the surface of the grate holes will be formed in the fire, through which the air passes without being deprived of its oxygen, or else lumps or piles in which the coal will be distilled without being completely burned.

The space between the grate-bars should be such that the fuel will fall through into the ash-pan only in the state of ashes or cinders vitrified by the temperature of the fire-box.

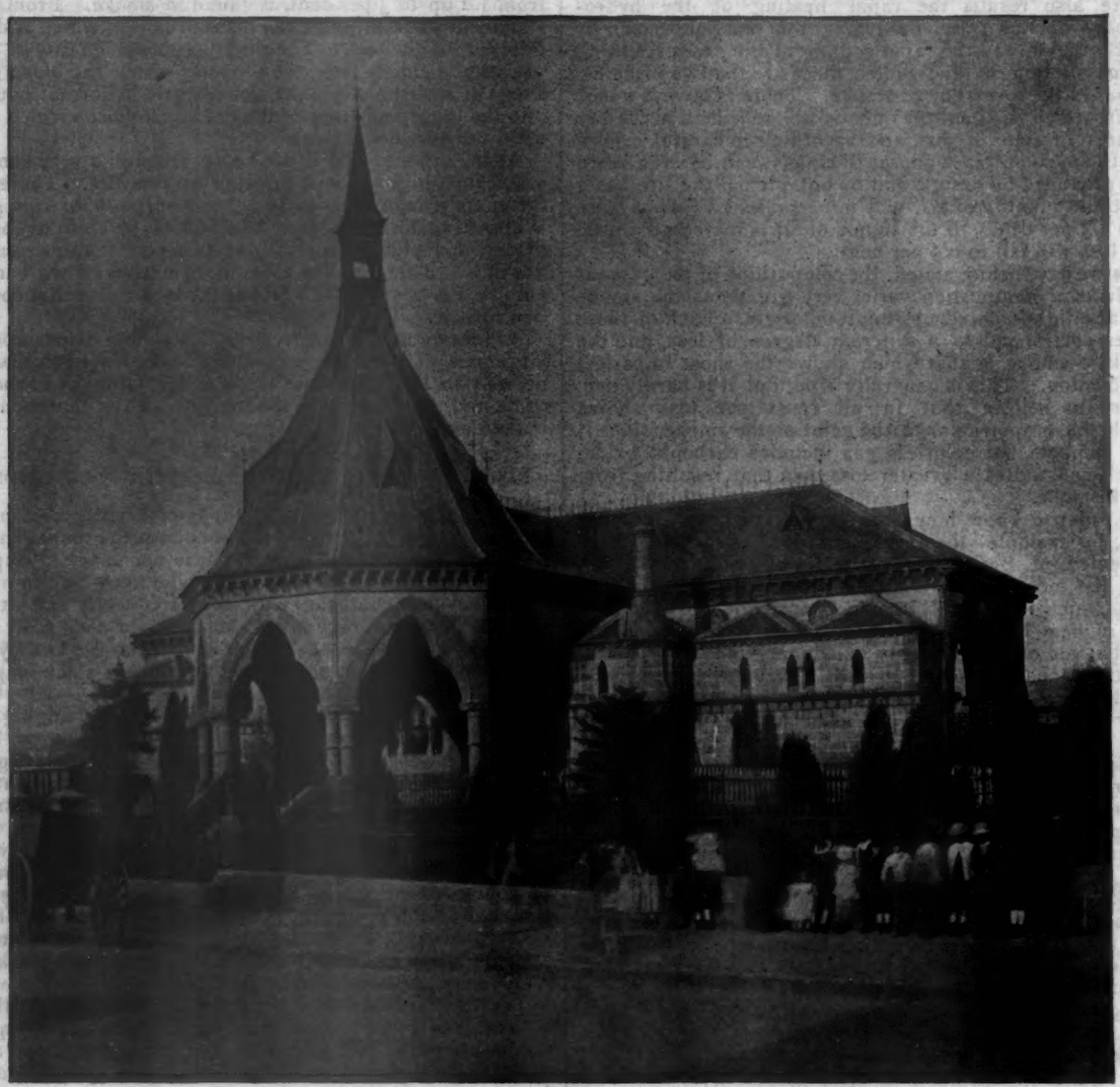
It is necessary to expose to the radiating or direct heat of the fire-box the greatest possible surface of the boiler in order that the greatest quantity of heat may be transmitted directly through its walls.

According to Peclet, in a locomotive boiler the quantity

of heat transmitted by direct radiation is almost three times that transmitted by contact for an equal surface.

In all boilers the fuel placed upon the grate acts in two ways. Combustion properly so-called gives the greatest amount of heat, since the gases traveling through the tubes are gradually cooled and give up only a part of the heat which they hold before reaching the smoke-stack. This difference of action is especially notable in boilers of the locomotive type with internal fire box and tubes, because in these the gases after having been burned in the combustion chamber suddenly encounter a large surface of a much lower temperature. The difference is not so marked in boilers of the Cornish type or in those without tubes or with return flues, but it still exists to some extent.

travel from the layer of coal on the grate to the smoke-stack. It is evidently because these gases on leaving the grate come immediately in contact with the boiler, which is, as we have said, a body sufficiently cool to partly extinguish these gases. We see, in fact, that the boiler at the pressure of 75 lbs. is at near 150° C., while carbonic oxide will not burn until it is at least at 800° C. and the hydrocarbons at 700° C., on account of the extreme dispersion of their particles. It follows then that the gases which leave the fire-box at a very variable temperature, not often at over 800° C., lose very quickly in contact with the boiler heat enough to reduce them to the temperature where they can no longer combine with oxygen. If it is possible then the complete combustion of all the gases leav-



"MORTUARY" STATION, SYDNEY, NEW SOUTH WALES. STREET FRONT.

While internal fire-boxes are favorable to the rapid absorption of heat, they have also some inconveniences. The height above the grate cannot be much more than 0.40 m., and we cannot use in them coals with a large proportion of gas, since the gases on coming in contact with the plates are cooled and cease to burn. The fuel to be employed in such boilers should have only a small proportion of volatile matter and should burn easily, since the walls of these fire-boxes do not attain a temperature of over 152° C., while in external fire-boxes the radiated heat of the brick walls will rise to 600° C., which is an important aid to combustion.

Let us see why the combustible gases and the oxygen of the air in excess do not combine in the path which they

ing the fire must be effected before they are cooled below the temperature where the fire is extinguished, whether it be 800° or 700°.

For the oxidation of a fuel and its volatile products—that is, for the combustion to be complete—it is necessary to break up the parallelism of the gaseous currents rising from the grate. When coal is distilled on an ordinary grate there are produced parallel currents of gas and of air, and combustion exists only on the lines of contact. When the air has lost one-half of its oxygen, and when the flame includes 10 per cent. of carbonic acid, this combustion ceases and there follows the production of black smoke and the consequent losses. Now if in any way there is a lateral injection of air—above the grate, for in-

stance—the gases will be forced to mix while they are still at a temperature above that of extinction. It is evident that they will combine, and we will thus obtain a much more complete combustion.

As to the quantity of air which must be introduced above the grate to produce an energetic mixture of gases close to the point where they are formed, it may vary between 10 and 20 per cent. of the total volume necessary to burn the fuel. Thus if we suppose that it requires 15 cub. m. of air to burn 1 kilogram of coal, we can admit from 12.5 to 13.5 cub. m. below the grate and from 2.5 to 1.5 above. If not more than 1 cub. m. should pass through, that would still be sufficient to break up the parallelism of the gaseous currents and to produce in the zone of high temperature the intimate mixture of all the elements which ought to combine. This mixture ought to be made at once and before the gases are too much cooled, in order to prevent the impoverishment of the air of its oxygen and the final production of carbonic acid.

If the air introduced above the grate can be heated to the temperature where it will inflame at once the gaseous products, the combustion will be much improved.

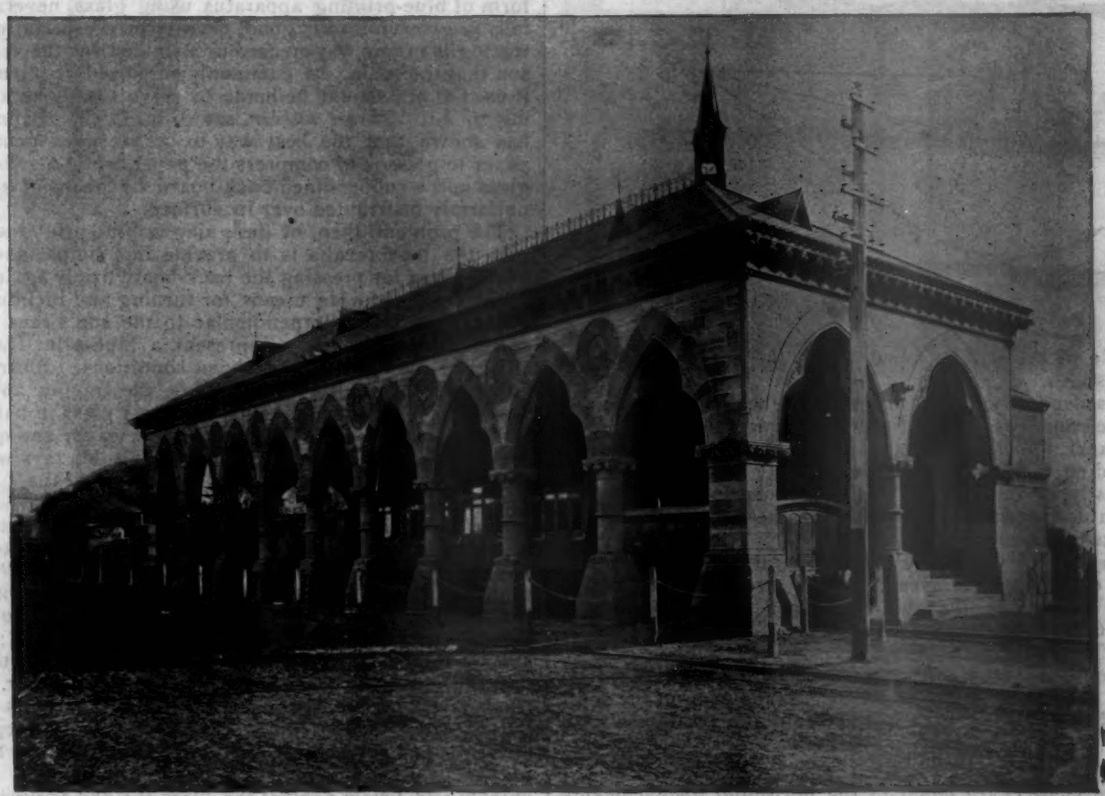
As can be easily understood, a grate which does not receive less than 10 to 15 per cent. of air above the fire cannot give good combustion when the flame is carried some distance from the fire-box; the parallel currents of gas, some of them consisting of combustible gases and carbonic acid, others of air charged with carbonic acid, all combustion becomes impossible. In consequence, where the temperature is too low at the origin in the fire-box, there is a loss by imperfect combustion and by black smoke if the coal is charged with gas. Jets of air break up the parallelism of the gaseous currents rising from the grate, the mass of gas is mixed to some degee in passing over the bridge where the section is contracted in comparison with that of the smoke-stack, and immediately the velocity of the currents decreases in the enlargement produced by the combustion chamber. The gases and air are completely mixed, the combustion is finished, and not until then do the products of combustion pass into the tubes.

(TO BE CONTINUED.)

AN AUSTRALIAN RAILROAD STATION.

THE accompanying illustrations, which are reproduced from photographs, show two views of a railroad station of very neat and tasteful design, which is placed at the entrance to a cemetery near Sydney, New South Wales, and is called the "Mortuary" station.

The first or larger engraving shows the street front. The building, as will be seen, stands on a slight elevation above the road, and its distinguishing features are the large arched porch and the tower surmounting it, which stand well out from the rest of the building. The offices and waiting rooms are placed on this front, and the entrance is by a wide flight of steps from the street.



"MORTUARY" STATION, SYDNEY, NEW SOUTH WALES. CEMETERY FRONT.

The second or smaller engraving shows the inside or cemetery front of the station. This is an open train-house with the roof supported by stone arches. The train standing in the house is apparently a funeral train.

The station is notable for its excellent design and adaptation to the surroundings.

TAKING THE PROFILE OF A RIVER BOTTOM.

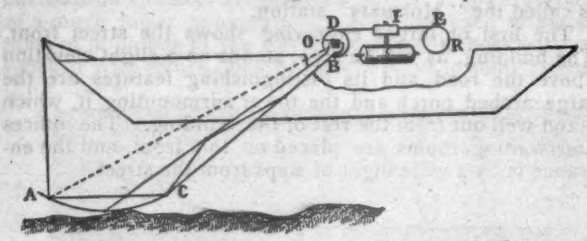
AN ingenious apparatus, invented by Herr Stecher and constructed by Herr Zeuner, at Dresden, was exhibited at the recent Internal Navigation Congress at Frankfort. It was specially designed for obtaining a profile of the bottom of the River Elbe, but might be applied with advantage in other places.

The apparatus consists of an arm or girder of angle-iron, *A B* in fig. 1, ending at *A C* in a curved point intended to slide along the bottom of the river. The other end of the arm is fixed by means of a yoke to a horizontal

shaft turning in bearings mounted on a boat. It will be seen that as the boat moves whenever a change occurs in the bottom, the curved end *A C* will rise or fall and will cause the shaft *O* to turn to a corresponding degree.

On this shaft a flexible band *D E* is rolled, which is kept in tension by means of a spring drum *R*. On this band is mounted a holder carrying a pencil *I*, the point of which traces, while the boat moves, upon a roll of paper which is gradually unrolled by a uniform movement, the

Fig. 1.



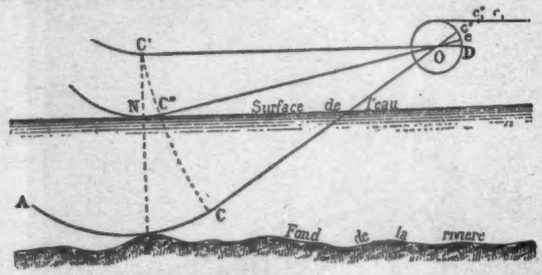


Fig. 2.

profile of the bottom, upon which the curved end of the arm slides.

A second pencil fixed in a position, which is determined at the commencement of the operation, traces on the roll of paper the line of depth—that is to say, the line corresponding to the surface of the water.

Lastly, a third pencil held by a spring permits the operator to mark, as the boat passes, the distances and other points on its course.

To explain the theory of the apparatus, the curved end *A C* of the arm is a section of a circle, which has the point *O* for a center and *O C* for a radius. It follows that *C F* = arc *C C'*; *C' N* = arc *C' C''*; and *C' F* − *C' N* = arc *C'' C*.

Now *C F* − *C N* is the depth looked for. This depth is then equal to the arc described by the arm on the shaft *O*, when the long arm passes from the position *O C* to *O C''* multiplied by the ratio $\frac{O C}{O D}$. But the arcs described by the shaft *O* are equal to the horizontal displacements of the flexible band; that is, to the displacement reduced by the pencil on the roll of paper. From this it results that the line obtained on the paper gives on the scale $\frac{O D}{O C}$, the depth of the river according to the line on the bottom followed by the arm *A C*.

The engineer in charge of the improvement of the Elbe says that the results obtained with this apparatus have been very satisfactory. In practice it was found that at smooth water the most convenient speed to obtain a given diagram was from 3½ to 6 miles an hour. The whole apparatus cost without the boat $175, including $25 royalty paid for the patent.

AN ACCURATE BLUE-PRINTING APPARATUS.

By George I. Rockwood, B.S.

The comfort of having one's blue-prints perfectly distinct and correct to scale is no slight one, especially if the scale is small and the drawing large, as, for instance, in the case of building plans. But it is a comfort rarely enjoyed, for prints are almost always distorted out of all truth, and often contain blurs due to lack of close contact with their negatives when printed.

There are two causes for the distortion of prints; in the first place, the printing frame may not have been so exposed that the sun's rays came perpendicularly upon the glass. This is of prime importance if the print is to be an accurate copy of the draft. In the second place, care may not have been taken to use a prepared paper which could stand the wetting and drying process without "coming and going."

In a not uncommon printing apparatus a large heavy piece of plate glass rests horizontally on a back-board covered with a thick and pliant felting, the board being mounted on four grooved wheels which fit into one half-inch half-round iron rails. The rails extend out of the room upon brackets fastened outside the window. The operator simply lifts up the glass, laying the paper and negative under it upon the felting, lowers the glass and runs the frame out-of-doors. This, although the simplest form of blue-printing apparatus using glass, nevertheless fails to give uniformly good, clear prints, especially if the tracing is in any way creased or wrinkled, for the very reason that the felting so commonly employed *is* pliant, and if used at all, should be made to serve simply as a backing to *hard gasket rubber*, say $\frac{1}{16}$ in. thick. Experience has shown that the best way to secure good contact of paper to glass is to compress the paper firmly between the glass and a rubber-lined back-board by means of springs uniformly distributed over its surface.

The problem, then, of designing a blue-print frame to give the best results is to provide in a simple and convenient way for pressing the back-board firmly against the glass, and to provide means for turning and inclining the glass into a plane perpendicular to the sun's rays. The accompanying drawings represent a blue-print frame so designed as to fulfill the above conditions. Blurring is effectually prevented by clamping the tracing and prepared paper tightly up against the plate glass in hard and uniform contact, and the glass may be easily and quickly secured in a plane perpendicular to the sun's rays without resorting to any complicated or cumbrous means.

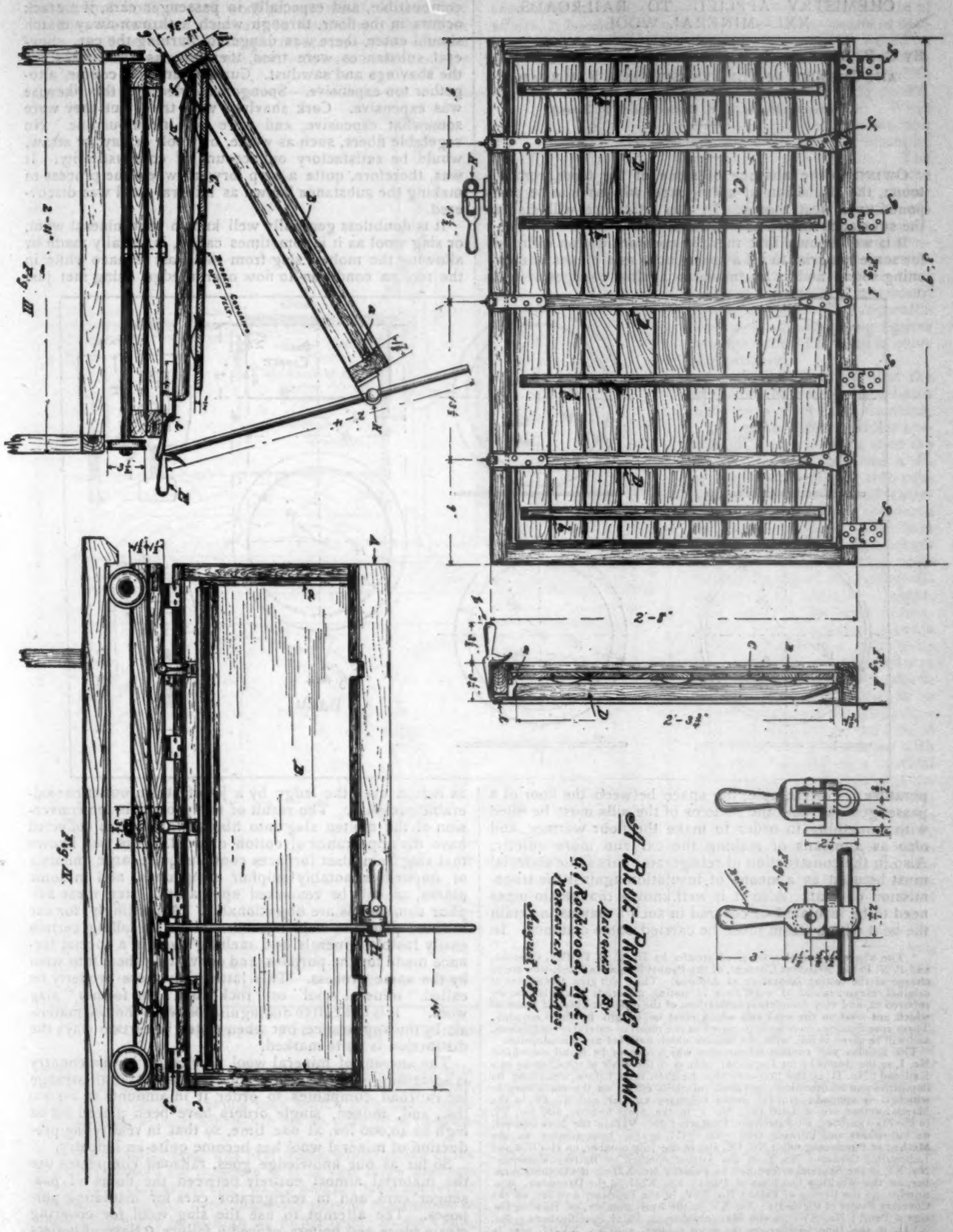
Figs. I and II show a plan and sectional view of the frame itself. Figs. III and IV show side and end elevations of the frame upon its truck, opened to receive the tracing and paper. The frame *A* holds the plate glass *B* in the same manner as a pane of window glass is held in its casing, but instead of using putty, narrow strips *a* should be screwed to the inside of the frame around its edges; these should not fit so tightly down upon the glass as to confine it rigidly, but must leave it with a little play. The tracing and paper are pressed between the glass and a back-board *C* composed of several strips cleated together at *b b b b* and covered with felting and sheet rubber tacked to the board around its edges. To press this board quickly and firmly against the glass the device illustrated was invented, consisting of three arms *D D D*, hinged at *f*, each carrying three springs and a cam-lever *E* hinged at *e*. After laying the paper and negative upon the back-board the frame is lowered upon its hinges *g*, until the glass rests upon the back-board, when a slight push upon each cam-lever easily locks its arm *D* into place and compresses its springs against the board. Figs. I and II show the arms thus clamped into place, while figs. III and IV show the frame open and ready for use.

The fixture illustrated in fig. V and shown in figs. III and IV at *H* is for clamping the frame at any desired angle upon the long rod pivoted upon the truck at *J*, and explains itself.

Two frames, *K* and *L*, support the printing frame proper, *K* being swiveled upon *L* to allow turning the frame about in any direction to meet the sun. The trolleys which support the apparatus should be drilled and turned on an arbor, as they will run enough more smoothly to compensate for the extra expense. The upper frame *K* should rest most of its weight upon one or two washers at the pivot-bolt so that it may be easily rotated without binding by friction on the lower frame.

It has not been found necessary to locate the frame in a dark room, but it is a good plan to have a large shallow

water tank for washing the prints placed directly underneath the rails supporting the frame, elevated a few inches above the floor and provided with faucet and waste pipe. Then the prints may be quickly whipped out of the frame and into the water without exposure in the transfer, and this otherwise unusable space in the drafting-room may be thus profitably utilized.



A Blue-Printing Frame

Designed By
G. I. Rockwood, M. E. Co.
Worcester, Mass.
August, 1891.

The praise uniformly accorded to this form of frame by those who have seen it in use justifies the belief in its practical value as an accurate blue-printing apparatus.

CONTRIBUTIONS TO PRACTICAL RAILROAD INFORMATION.*

CHEMISTRY APPLIED TO RAILROADS. XXI.—MINERAL WOOL.

By C. B. Dudley, Chemist, and F. N. Pease, Assistant Chemist, of the Pennsylvania Railroad.

(Copyright, 1889, by C. B. Dudley and F. N. Pease.)

(*Continued from page 404.*)

Owing to the absence of some of the force from Altoona, the discussion of spring steel will have to be postponed until next month. In this article we will discuss the substance known as "Mineral Wool."

It is well known that there is constant use on railroads for some material to fill a space, both as a means of deadening sound and as an insulator against changes of temperature. For example, the space between the floor of a passenger car and the bottoms of the sills must be filled with something in order to make the floor warmer, and also as a means of making the car run more quietly. Also in the construction of refrigerator cars some material must be used as a means of insulation against the transmission of heat. Also it is well known that steam pipes need to be insulated or covered in such a way as to retain the heat where steam must be carried some distance. In former times shavings and sawdust were used to quite an extent for the first two of these purposes, and various other devices for the latter. Unfortunately these substances are combustible, and especially in passenger cars, if a crack occurs in the floor, through which a thrown-away match should enter, there was danger of burning the car. Several substances were tried, therefore, as substitutes for the shavings and sawdust. Curled hair is, of course, altogether too expensive. Sponge was tried, but this likewise was expensive. Cork shavings were tried, but they were somewhat expensive, and were not incombustible. No vegetable fibers, such as waste, or wool, or hay, or straw, would be satisfactory on account of combustibility. It was, therefore, quite a step forward when the process of making the substance known as mineral wool was discovered.

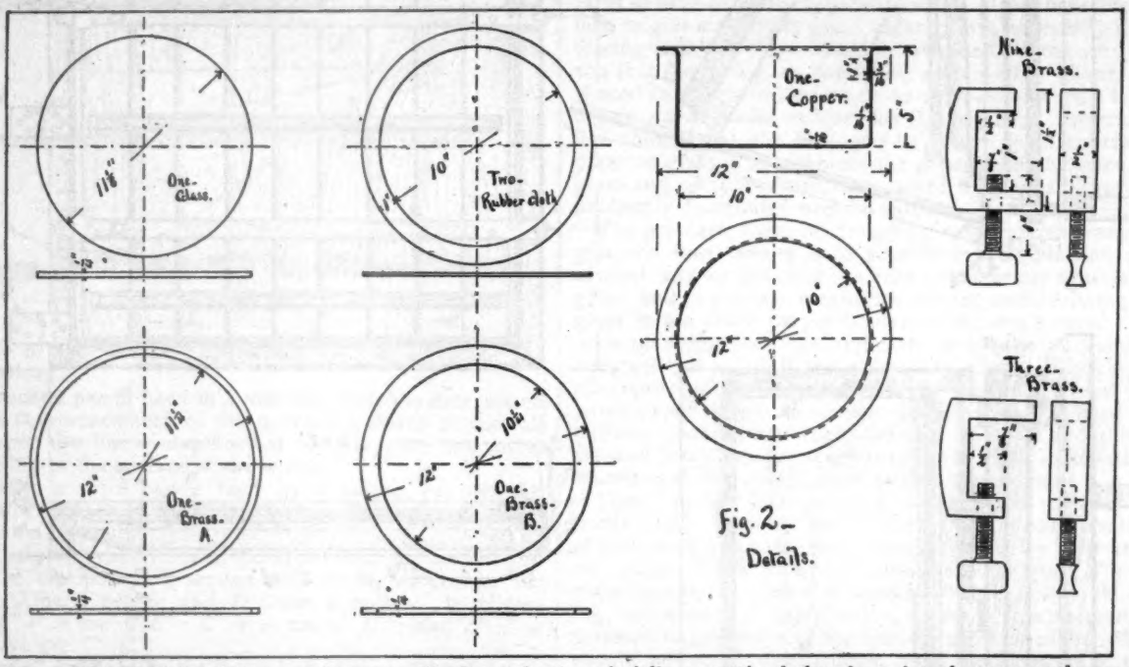


Fig. 2.—Details.

It is doubtless generally well known that mineral wool, or slag wool as it is sometimes called, is usually made by allowing the molten slag from the blast furnace while in the molten condition to flow over a ledge, being met just as it falls over the ledge by a jet of steam under considerable pressure. The result of this process is the conversion of the molten slag into fibers, which when collected have the appearance of cotton or wool. It is well known that slag from blast furnaces contains quite large amounts of impurities, notably sulphur compounds, and in some places, as will be remarked upon a little later, these sulphur compounds are objectionable. Accordingly, for use in these places, a wool has been made by taking certain easily fusible minerals and melting them in a special furnace made for the purpose, and converting them into wool by the same process. This latter may more properly be called "mineral wool" or "rock wool," the former "slag wool." It is difficult to distinguish between the two materials by the appearance, but when tested in certain ways the distinction is quite marked.

The amount of mineral wool now made in this country is something quite considerable. It is not at all strange for railroad companies to order it in amounts of 20,000 lbs., and, indeed, single orders have been placed for as high as 40,000 lbs. at one time, so that in reality the production of mineral wool has become quite an industry.

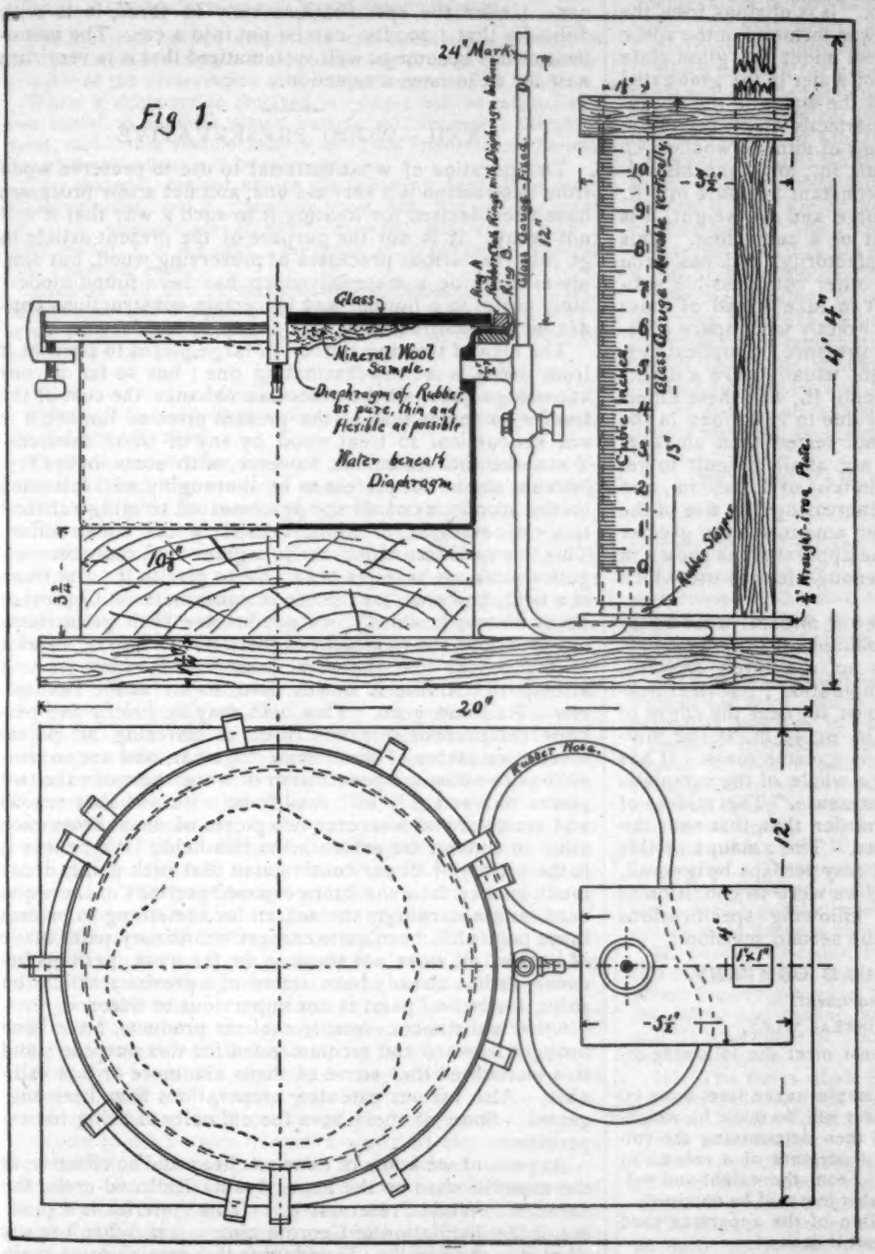
So far as our knowledge goes, railroad companies use the material almost entirely between the floors of passenger cars, and in refrigerator cars for insulating purposes. The attempt to use the slag wool for covering steam pipes and boilers proved a failure. Several boilers and quite a number of steam pipes were at one time covered with this material, but wherever a leak occurred, causing the condensed water to reach the wool, chemical action started, decomposing the sulphur compounds, with

* The above is one of a series of articles by Dr. C. B. Dudley, Chemist, and F. N. Pease, Assistant Chemist, of the Pennsylvania Railroad, who are in charge of the testing laboratory at Altoona. They will give summaries of original researches and of work done in testing materials in the laboratory referred to, and very complete specifications of the different kinds of material which are used on the road and which must be bought by the Company. These specifications have been prepared as the result of careful investigations, and will be given in full, with the reasons which have led to their adoption.

The articles will contain information which cannot be found elsewhere. No. I, in the Journal for December, 1889, is on the Work of the Chemist on a Railroad; No. II, in the January, 1890, number, is on Tallow, describing its impurities and adulterations, and their injurious effects on the machinery to which it is applied; No. III, in the February number, and No. IV, in the March number, are on Lard Oil; No. V, in the April number, and No. VI, in the May number, on Petroleum Products; No. VII, in the June number, on Lubricants and Burning Oils; No. VIII, in the July number, on the Method of Purchasing Oils; No. IX, also in the July number, on Hot Box and Lubricating Greases; No. X, in the August number, on Battery Materials; No. XI, in the September number, on Paints; No. XII, in the October number, on the Working Qualities of Paint; No. XIII, in the December, 1890, number, on the Drying of Paint; No. XIV, in the February number, on the Covering Power of Pigments; No. XV, in the April number, on How to Design a Paint; No. XVI, in the May number, on Paint Specifications; No. XVII, in the June number, on the same subject, and No. XVIII, also in June, on the Livering of Paint; No. XIX, in the July and August numbers, on How to Design a Paint; No. XX, in the September number, on Disinfectants. These chapters will be followed by others on different kinds of railroad supplies. Managers, superintendents, purchasing agents and others will find these Contributions to Practical Railroad Information of special value in indicating the true character of the materials they must use and buy.

the result of very serious corrosion of the boiler plate or steam pipes. Accordingly the use of slag wool for this purpose was abandoned. We understand, however, that the mineral wool, or rock wool proper, which was used by the New York Steam Company in insulating their steam pipes, was free from this difficulty on account of the absence of sulphur compounds in the minerals used in making the wool. So far as our knowledge goes, railroad companies do not use mineral wool for steam pipe or boiler coverings, other materials being used which give more satisfactory results, and which are not so difficult of application.

When mineral wool was first made, examination of the material showed the presence in it of very large amounts of little globules of the slag, which had not been converted into fiber. Careful determinations showed the amount of these globules to be as high as 30 per cent., 40 per cent., or even as high as 60 per cent. of the weight of the wool. In view of the fact that the consumer buys this material for the sake of filling a space, and pays for it by the pound, it is obvious that the globules are a very serious detriment. He pays the same price for globules that he does for mineral wool, while the globules are practically of no value. These globules vary in size, from mustard seed up to as large as small peas. In view of this state of affairs, it became necessary to devise some means of testing this material in such a way that the use of it would be more economical, a problem which was not free from difficulty. Here is a compressible substance bought by the pound, and used to fill a space. What test can be applied to prove how much a cubic foot, for example, of the material weighs? The difficulties were to obtain the weight of a cubic foot, or any convenient measure, and to obtain this under the same conditions at all times, it being obvious that if the material was more compressed at one time than another, the results of test would not be uniform. The apparatus shown in accompanying figures was accordingly devised to solve this problem.



APPARATUS FOR TESTING MINERAL WOOL.

It will be observed that the apparatus is essentially a basin some 10 in. or 12 in. in diameter, 3 in. or 4 in. deep, with flat bottom and vertical sides, over the top of which is stretched a diaphragm of extremely thin rubber, which rubber is held watertight to the edges of the basin by suitable clamps; also that there is a thick glass plate which may be held in a constant position on the top of this rubber diaphragm by suitable clamps. The inside of the basin is connected by a side opening and a rubber tube, with a glass tube graduated into cubic inches and tenths, which graduated tube is mounted in such a way as to be raised or lowered vertically on a standard situated by the side of the basin. Also connected with this side opening is a vertical gauge glass which indicates the water level when the material is under test. The basin is completely filled with water up to the diaphragm, care being taken to get all the air out, and also the rubber tube and graduated glass tube are likewise part filled with water.

The method of using the apparatus is as follows: The glass plate being placed over the rubber diaphragm, and clamped in a definite position, the graduated tube is raised until the water in the gauge tube has assumed a constant, pre-determined standard height, which in our case is two feet. Of course as the graduated tube is raised, the water in the tube runs down into the basin and presses the rubber diaphragm up against the glass plate, and it is essential to have the water level in the graduated tube, when everything is at rest, two feet above the level of the water in the basin under the diaphragm, and also have it so that its level can be read in the graduations. When this is done the reading is made, and we will suppose that the water stands in the graduated tube at the graduated mark one inch. The glass tube is now lowered, and the water allowed to run back into this tube, the clamps holding the glass plate are loosened and the plate removed. A previously weighed handful of mineral wool is now laid on

top of the rubber diaphragm, care being taken to spread it around a little, so that it will not be in too compact a lump. The glass plate is then replaced and the clamps put in their former position. The graduated tube is then raised, the water running back into the basin, and gradually beginning to compress the diaphragm around the wool. A little adjustment is required, until in perhaps five minutes the water in the gauge tube will assume a constant position at the 2-ft. mark. It is obvious from the description that the water which was formerly in the space now occupied by the mineral wool under the glass plate appears in the increased volume of water in the graduated tube. We will suppose that now the water in the graduated tube reads 4.30 in. It is perfectly clear, therefore, that the volume occupied by the tuft of mineral wool which is under the glass plate is 3.30 cub. in., and that this volume has been obtained under a constant pressure of 2 ft. of water. Knowing now the volume and the weight, it is very easy to calculate the weight of a cubic foot. This apparatus has worked very satisfactorily, and has been used to obtain the volume of other compressible substances. It is not at all difficult to take a wad of loose cotton or a bit of waste and say exactly what space it occupies under any predetermined pressure. Duplicate experiments on mineral wool do not usually show a difference of over 0.30 or 0.40 lb. per cub. ft., and these differences, we think, are more largely due to variations in the different samples of mineral wool tested than an inaccuracy in the apparatus. It is not at all difficult to get duplicates on wool waste to within 0.05 of a cub. in., and it is of course obvious that by increasing the size of the apparatus and working on larger amounts, even greater accuracy could be obtained. The apparatus, as shown in the cuts, is apparently accurate enough for the use which we make of it.

It will be observed that the layer of mineral wool under the diaphragm which is being measured has some perceptible thickness, which thickness is not absolutely uniform. It depends something on the manipulation ; but the thickness of the layer may vary from 0 01 in. near the edges of the sample tested to possibly ¼ in. or ⅜ in. at the middle of the sample, where there is greater mass. It has not escaped our attention that the whole of the sample is not under absolutely the same pressure. The middle of the sample is squeezed a little harder than that near the edges, where the layer is thinner. The amount of this error, however, is very small, and may perhaps be ignored. After this apparatus was devised, we were in condition to prepare specifications, and the following specifications were issued, this draught being the second revision :

PENNSYLVANIA RAILROAD COMPANY.

Motive Power Department.

SPECIFICATIONS FOR MINERAL WOOL.

From this date Mineral Wool must meet the following requirements :

On receipt of shipment, three (3) samples taken from three (3) different bags will be tested. The test will be made by weighing a small sample of the wool, and then determining the volume occupied by this sample under a pressure of a column of water twenty-four (24) inches high. From the weight and volume of the sample the weight per cubic foot will be obtained.

Blue prints showing the construction of the apparatus used in determining the volume will be sent if desired.

Shipments will not be accepted of which the average weight of the three (3) samples tested as above exceeds fifteen (15) pounds per cubic foot.

THEODORE N. ELY,
General Superintendent Motive Power.

Office of General Superintendent Motive Power, Altoona, Pa., June 10, 1887.

It should be stated that the material is usually shipped in bags for convenience in handling, and it will be observed that in view of the probable lack of uniformity of the material made in such a crude way, we take samples from three different bags, using the average as the figure on which to base acceptance or rejection. At first we attempted to get a wool which did not weigh over 10 lbs. per cub. ft. ; but it was soon found that only a little such wool was made at each place where the manufacture was conducted, and that it would be difficult for us to supply ourselves with so good an article as this. Improvements have now been made in the process, we believe, with the result that a better grade is made than formerly—that is, the wool contains fewer of the slag globules. The first samples tested before the specifications were issued weighed from 30 lbs. to 40 lbs. per cub. ft., owing to the presence of the slag globules previously mentioned ; and it used to take 3,000 lbs. of mineral wool to fill a passenger car. Under the specifications now in force, it is with difficulty that 1,200 lbs. can be put into a car. The manufacture has become so well systematized that it is very rare now for us to have a rejection.

XXII.—WOOD PRESERVATIVE.

THE question of what material to use to preserve wood from destruction is a very old one, and not a few processes have been devised for treating it in such a way that it will not decay. It is not the purpose of the present article to go into the various processes of preserving wood, but simply to describe a material which has been found moderately useful in a limited way in certain constructions connected with railroads.

The idea of treating timber in large pieces to prevent it from decay is a very fascinating one ; but so far as our knowledge goes, all the processes enhance the cost of the timber so much that at the present price of lumber it is not economical to treat wood by any of these methods. We make this statement, however, with some hesitancy, because we do not profess to be thoroughly well informed on the economies of all the processes of treating railroad ties, for example, or timbers used in car construction. This is a question which needs a great deal more investigation than we have yet been able to give to it. But there is a field, however, for the use of some material to prevent decay of wood, which does not involve such great items of expense as the treatment of the wood *en masse ;* and it is in this field that the wood preservative which we will attempt to describe is mostly used, so far as the Pennsylvania Railroad goes. This field may be briefly and perhaps comprehensively described as covering all points where two pieces of wood come together, and are so situated as to allow the penetration of water between the two pieces of wood. It will readily be observed that tenons and mortises and wherever two pieces of wood cross each other in contact are embraced in this field. We believe it is the history of all car construction that such points decay much sooner than the more exposed portions of the wood used, and accordingly the search for something to protect these points has been quite earnest. Ordinary paint made of linseed oil does not seem to do the work, perhaps because, as has already been stated in a previous article on paint, linseed oil paint is not impervious to water.

Other substances, notably coal tar products, have been brought forward and recommended for this purpose ; and it is undoubted that some of them are more or less valuable. Also various patented preparations have been suggested. Some of these have the difficulty of being too expensive.

At present we know of none so cheap and so effective as the material used on the Pennsylvania Railroad under the name of " Wood Preservative." This material is a product of the distillation of Georgia pine. It is difficult to say what it is chemically. It undoubtedly contains some rosin oil, and may contain some chemical bodies which are constituents of creosote. It also contains considerable material which is similar in nature to spirits of turpentine, although we do not think they are identical in composition. This material, when painted over wooden surfaces with one or two coats and allowed to soak in, is a very good protection against water, and seems also to have the remarkable power of converting many of the soft woods into much firmer material. Sticks of pine soaked in it become changed in color and very much more solid, more difficult to cut, and considerably heavier. When exposed to water it seems to have very little action on them. The soaked material looks like the substance known as " fat pine." This material is also believed to be a complete protection against the action of the teredo on piles driven in salt water.

After two or three years of experiments the use of this material became quite extended, and accordingly specifications were prepared in order to get a uniform product. These specifications are as follows :

PENNSYLVANIA RAILROAD COMPANY.

Motive Power Department.

SPECIFICATIONS FOR WOOD PRESERVATIVE.

The material desired under this specification is a product of the distillation of Georgia Pine, containing as large an amount as possible of the preservative acids characteristic of this distillate.

When a shipment is received, a sample will be taken from one barrel at random, which sample will represent the shipment, and if this sample fails to meet the requirements below, the whole shipment will be returned.

The material desired shows the following figures on test: Flashing point, 200° F. ; burning point, 220° F. ; specific gravity, 1.05 ; temperature at which material will run, 15° F. ; tarry matter, 5.00 per cent. ; tar acids, 45.00 per cent. ; neutral oils, 50.00 per cent.

Material will not be accepted which flashes below 172° F., burns below 200° F., has a gravity less than 1.03, will not run at 20° F., has more than 12.00 per cent. of tar, or less than 30 per cent. of tar acids.

THEODORE N. ELY,
General Superintendent Motive Power.

Office of General Superintendent Motive Power, Altoona, Pa., August 7, 1889.

The reason why for each of the various tests is as follows : At first the material used was so low in flashing point, owing to the very light products that it contained, that it was a little dangerous to use, having the same danger that is characteristic of benzine, namely, vaporizing readily and mixing with the air, forming an explosive mixture, and accordingly flashing and burning points were determined. The specific gravity is taken as one of the checks to prevent inferior materials being mixed with it, as very few organic materials have so high specific gravity as 1.00. The tarry matter may be regarded as a species of pigment or paint which stays on the surface. In view of the fact that this material seems to have its best influence when soaked into the wood, our specifications desire to make the amount of tarry matter as small as possible. The tar acids are believed to be the most valuable wood preservative elements, although, as stated above, our knowledge of the chemistry of these substances is so limited that it is difficult to say which are the most valuable elements. The tarry matter and the tar acids being determined, the neutral oils are determined by difference.

The method of testing is as follows : The fire test is taken in the ordinary way exactly the same as for burning oils. The specific gravity is taken with a hydrometer, and the cold test, or temperature at which the material will run, is done in the same way as described for oils. The tarry matter is determined by taking 20 cubic centimeters in a 100-cubic centimeter stoppered graduate, and diluting with 88° gravity gasoline to 100 cubic centimeters. The tar is insoluble in gasoline, and either precipitates to the bottom in such a way that the amount can be read off or sticks to the sides of the vessel. In the latter case, of course it is impossible to read the amount of the tar, and we accordingly proceed as follows : Have a second 100-cubic centimeter graduate which has had some gasoline in it and then poured out and drained. After the material has separated completely, quickly pour off from the full graduate into the empty one all the liquid, taking care not to allow any of the tar to run out. Read off now from the second graduate the amount of solution, which will always be less than 100 cubic centimeters. It is obvious that the difference is the amount of tar plus the small loss by vaporization during the operation. The error due to vaporization under careless manipulation might be considerable ; but we are inclined to think with some experience and good manipulation the error does not amount to over 1.00 or 2.00 per cent. As the limits of our specifications are moderately wide, we have never had occasion to reject a shipment from the errors of measurement.

The tar acids are determined by taking 80 cubic centimeters of the clear gasoline solution just described, and adding to it 20 cubic centimeters of a water solution of caustic soda, which has the strength corresponding to the specific gravity of 13° Beaumé. We also add 4 cubic centimeters of alcohol, and then mix thoroughly by shaking, the operation being performed in one of the 100-cubic centimeter graduates above described. Under this treatment the tar acids combine apparently with the soda, and go into the water solution, increasing its volume. The material separates into two distinct layers. The line of demarkation is very sharp, provided the alcohol has been used. At first, before alcohol was used, we could not get a sharp line of demarkation ; but with the alcohol the line is sharp enough for good reading. A preliminary experiment without the tar acids being present showed that three cubic centimeters of the alcohol goes into the soda solution and one into the gasoline solution. It is, therefore, necessary to diminish the volume of the soda solution by three. The increase minus these three cubic centimeters of alcohol shows the volume of the tar acids in the 80 cubic centimeters of the gasoline solution which was used. From this data it is not difficult to calculate the percentage of tar acids in the original material.

The manufacture of this material is so uniform now that it is very rare that we have any rejections, and the use of the material is constantly on the increase. It is possible that if the price should diminish it might ultimately be found advantageous to treat timber *en masse* ; but thus far the use of the material has been confined largely to the places specified in accompanying circular :

PENNSYLVANIA RAILROAD COMPANY.

Motive Power Department.

INSTRUCTIONS IN REGARD TO THE USE OF WOOD PRESERVATIVE.

The valuable qualities of Wood Preservative as a means of preserving wood from decay having been demonstrated by careful experiments, it is desired to make the use of this material more general. From this date Wood Preservative will be used as follows :

I. On all tenons and in all mortises in both Passenger and Freight Car work, and in the wood work of Tenders and Cabs, except as specified in Sections V and VI. The skeletons of Passenger Equipment cars, as well as the backs of panels, should be coated with Wood Preservative instead of with Freight Car color as heretofore. If the piece of wood is small it is well to dip the tenon in the liquid. In all other cases it should be applied with a brush, and care should be taken to have as much of the Wood Preservative taken up by the wood as possible. The shoulders of the tenons and the shoulder seat should be included in the treatment, as it is found that the water, which gets in between the shoulders and shoulder seats, causes rapid decay in these places.

II. In all Passenger, Freight, Tender and Cab work, where two pieces of wood touch each other, at least one good coat of Wood Preservative must be interposed, except in the joints of the siding and roofing, and except as specified in Sections V and VI ; the roofs of Cabs must have at least two coats before the tin is put on.

III. The floors of all Stock Cars and of cars engaged in the manure trade, and all that part of the Tender floor which is covered by the cistern, must have at least two good coats of Wood Preservative. It is also recommended to use Wood Preservative on tenons and in mortises of Shop buildings and all over floor timbers and on underside of flooring, especially where the ground is damp and ventilation poor.

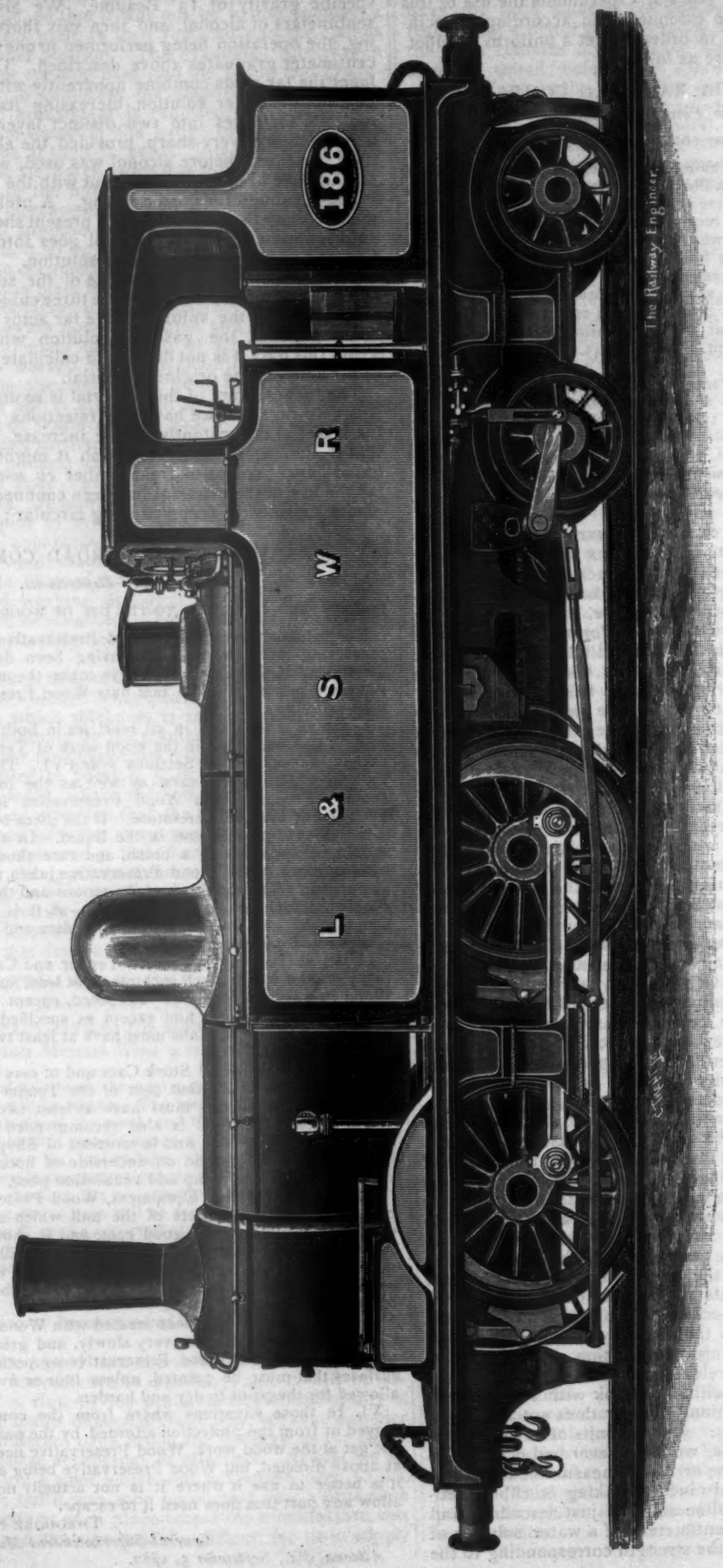
IV. On the Floating Equipment, Wood Preservative should be used freely. All parts of the hull which are submerged should have at least one good coat, and it should be used on tenons and in joints everywhere, where it will not interfere with the paint as described below. The floors of Ferry Boats under the sheathing, and the sheathing itself should have not less than two coats.

V. On wood that has been treated with Wood Preservative, it is found that paint dries very slowly, and great care should be taken not to use Wood Preservative or permit it to get on surfaces that must be painted, unless four or five days can be allowed for the paint to dry and harden.

VI. In those situations where from the construction employed or from the protection afforded by the paint, water cannot get at the wood work, Wood Preservative need not be used as above directed, but Wood Preservative being a preservative, it is better to use it where it is not actually needed, than to allow any part that does need it to escape.

THEODORE N. ELY,
General Superintendent Motive Power.

Altoona, Pa., September 5, 1887.



TANK ENGINE FOR SUBURBAN TRAFFIC, LONDON & SOUTHWESTERN RAILWAY.

DESIGNED BY WILLIAM ADAMS, LOCOMOTIVE SUPERINTENDENT.

We hope to take up the question of springs in the next article.

(TO BE CONTINUED.)

AN ENGLISH LOCOMOTIVE FOR SUBURBAN SERVICE.

THE accompanying illustration, from the *Railway Engineer*, shows a new tank engine of a class lately designed by Mr. William Adams, Locomotive Superintendent of the London & Southwestern Railway, for working the heavy suburban traffic of that road. They are intended to take the place of a lighter class of engines, and the company is now building 40 of them at its Nine-Elms shop; several of them are already at work.

The engine, it will be seen, is of the Forney type, but follows English practice in the plate frames and inside cylinders. It is carried on four coupled driving-wheels and a four-wheeled truck.

The boiler barrel is 50 in. in diameter and 9 ft. 3½ in. long. There are 210 tubes 1¾ in. in diameter and 9 ft. 9 in. long. The grate area is 13.8 sq. ft.; the heating surface is: Fire-box, 90; tubes, 898; total, 988 sq. ft.

The cylinders are 17 in. in diameter and 24 in. stroke. The driving-wheels are 58 in. in diameter and the truck wheels 36 in. The driving-axles are spaced 6 ft. 10 in. between centers, and the distance from center of rear driving-axle to center of truck is 11 ft. The truck axles are 5 ft. apart. The total length of the engine over all is 30 ft. 8½ in.

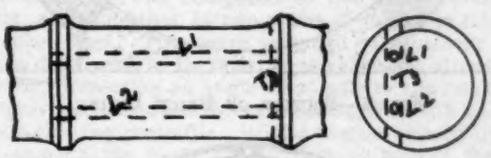
The water-tank holds 800 galls. of water, and the coal-box 2¼ tons of coal. The total weight of the engine in working order is 99,800 lbs., of which 66,100 lbs. are carried on the four driving-wheels, and 33,300 lbs. on the truck.

In building these engines cast steel has been used wherever possible, a practice which Mr. Adams has followed for some time. Those already completed are giving very good results in service. This engine might be compared with the New York Central Suburban locomotive which was described and illustrated in the September number of the JOURNAL, which is a little heavier.

A MATTER OF IMPORTANCE TO RAILROADS.

THE not infrequent breaking of crank-pins of locomotive engines is a source of accident and expense, and a method of avoiding it, without making the pins unnecessarily large and heavy, is very desirable.

The Second Vice-President of the Lehigh Valley Railroad, on a trip over the line recently, experienced some delay on account of the breaking of the main crank-pin of the locomotive. He at once directed that a part of this pin be sent to the Bethlehem Iron Company for analysis. This was done, and showed a good quality of steel. Pieces were then subjected to physical test, which also indicated a good grade of metal. Then the pin had an inch hole drilled through it, and was oil-tempered and annealed. After treatment a test specimen was cut from the pin and subjected to a physical test. The result was an increase in tensile strength of 7.7 per cent.; in elastic limit of 36.6 per cent.; in extension of 34.9 per cent., and in contraction of area at point of fracture of 39.1 per cent.



The accompanying table shows the result of this test. The first three lines, specimens *L.*1, *L.*2 and *T.*3, show tests of specimens of the metal, both longitudinal and transverse sections. The small diagram, fig. 1, shows the way in which the specimens were cut from the broken pin. The transverse specimen, marked *T.*3, was taken from the smooth part of the fracture. The fourth line, marked *H.S.L.*2, shows the results obtained from the test of the metal after treatment. A study of this table will tell the story at once.

The results of this test were so striking that instructions were at once given that 20 locomotives now being built at the Baldwin Locomotive Works for the road should be furnished with steel crank-pins oil-tempered and annealed, and all pins hereafter used will be of the same character. It has also been decided that all pins hereafter used upon pin-connected bridges shall be treated in the same way.

It may also be mentioned that the Lehigh Valley Company is now having two sets of locomotive tires oil-tempered and annealed, and excellent results are expected from the treatment. In fact, the results of these experiments would seem to indicate that it would be well to have the guides, connecting-rods and other parts of the locomotive now made of steel treated in a similar way.

TEST OF DRIVER PIN BROKEN JULY 31, 1891, ON ENGINE "IDLEWILD."

Mark on Specimen.	Dimensions.		Test.				Appearance of Fracture.	Remarks.
	Size.	Length.	Tensile Strength.	Elastic Limit.	Per cent. Extension.	Per cent. Contraction.		
L. 1	0.499"	2"	88,970	39,880	17.25	43.50	Irreg. gray cryst. specks.	Specimen cut from pin as received.
L. 2	0.499"	2"	88,460	39,880	17.25	43.50	" " " "	" " " " " "
T. 3	0.500"	2"	94,220	39,720	16.85	21.49	Cryst. gray spot on edge.	" " " " " "
H.S.L. 2.	0.498"	2"	97,540	54,430	23.10	50.31	Dense gray lipped.	From piece of pin after boring hole 1" in diameter, and oil-tempering and annealing.

Specimens all from crank-pin Lehigh Valley Railroad locomotive No. 416, broken in service.
Analysis: Carbon, .53; manganese, .59; phosphorus, .047; sulphur, .069; silicon, .170.

THE GLASGOW HARBOR TUNNEL.

(From *Industries*.)

THE work on this tunnel was begun in May, 1890, and it is expected that it will be finished early next year. It extends under the river Clyde, where it forms the harbor of Glasgow, and is intended to furnish a crossing for passengers and vehicles at a point some distance below any of the present bridges and where a bridge of any kind except at a very high level would be an obstruction to navigation. It is built by a corporation known as the Glasgow Harbor Tunnel Company, the contract being taken by Hugh Kennedy & Sons, Partick, Scotland.

The work consists of three separate tunnels, two being intended for vehicles and one for foot passengers. The approaches to the tunnels are formed by circular shafts, in which will be fitted flights of stairs and hydraulic elevators. These elevators will be made capable of taking maximum loads of 10 tons, and will be so arranged as to avoid any delay in ascending or descending the shafts. It will be seen by the plan that all three tunnels connect at each end with the same shaft.

Each shaft is circular, and has a diameter of 80 ft.;

that on the north side being 72 ft. 6 in. in depth, and that on the south side being 3 ft. deeper. The excavation of the shafts or walls is carried on inside an open double-skinned lining, which descends by its own weight as the removal of material proceeds. The work of excavation has been done in 10-ft. lengths, and in the customary manner. A few boulders of size have been met with, but their removal has been readily effected. The cast-iron lining of the tunnels, see fig. 4, will be composed of segments in rings 18 in. long. Each segment will be

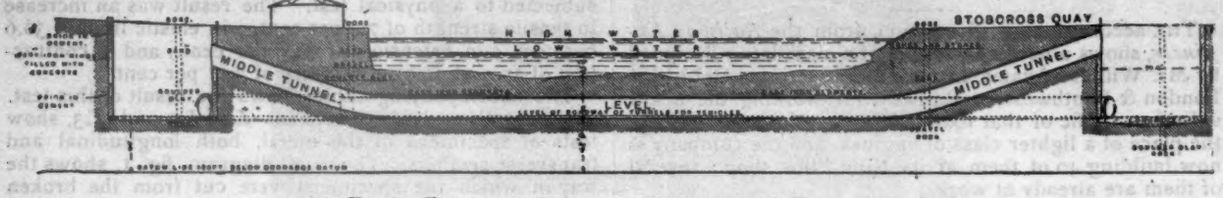


FIG. 1.—TRANSVERSE SECTION OF RIVER, SHOWING TUNNELS AND SHAFTS.

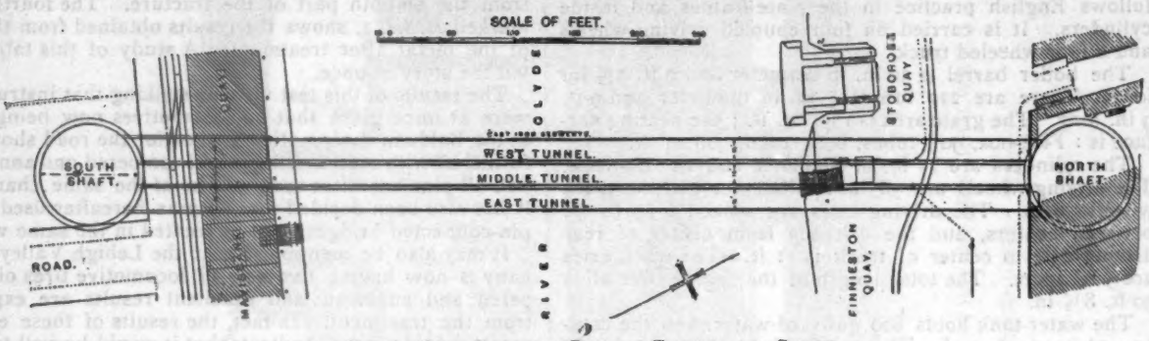


FIG. 2.—PART SECTIONAL PLAN OF TUNNELS AND SHAFTS.

THE GLASGOW HARBOR TUNNEL.

has been performed by hand labor filling skips worked by steam cranes situated on the surface. The skins of the lining are composed of cast-iron plates, each 4 ft. long by 2 ft. in depth, with a flange inside all round 3 in. in depth, and of ½-in. metal throughout. The plates are bolted together by ½-in. bolts, spaced 12 in. apart, about ⅛-in. space being left between the flanges for wedging with soft wood, a mode of packing the joints which has proved highly satisfactory and water-tight under considerable pressure. The skins are tied together at the top of each tier of plates by malleable iron ties, 3 ft. deep by ½ in. thick, secured to the flanges by ½-in. bolts. The lining is armed with a cutting edge to facilitate its descent. The space between the inner and outer skins of the lining is filled with concrete composed of five parts of broken stone and sand to one part of cement. As the lining descends, fresh segments are added. Both shafts have now been successfully sunk to their full depth, that on the north side passing entirely through running sand. The pumps had, however, no difficulty in coping with all water met. On the south side an inclined bed of boulder clay was met after passing through the running sand, and it was found necessary to weight one side of the caisson to insure vertical descent. The boulder clay is of a particularly hard and stiff nature, and affords an excellent foundation for the caisson.

Passing to the tunnels, which, as we have explained, are three in number, two for vehicular traffic and one for passenger traffic, their construction will be noted from the accompanying cross sections, partly lined with brick, fig. 3, and partly with cast iron, fig. 4. The tunnels are only 2 ft. apart from each other, and their crowns are about 15 ft. below the river bed, allowing therefore ample margin for future dredging operations. In the boulder clay, where the tunnels are brick-lined, their diameter is 18 ft., while beneath the river, where cast-iron segments will be employed, the diameter is 2 ft. less.

The portion through boulder clay, fig. 3, is constructed on a concrete invert flooring, with circular brick lining composed of five rings of brickwork set in cement. The west tunnel is constructed for 150 ft. under the river on the south side, and preparations are in hand for commencing work with the second shield in the east tunnel, which is now driven 100 ft. also from the south side. The construction of the tunnel so far calls for no special remark.

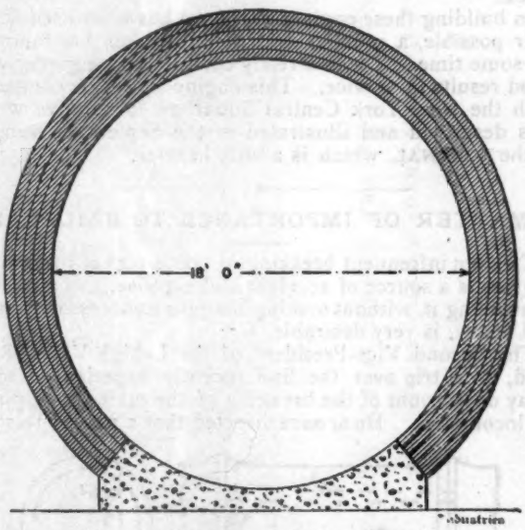


FIG. 3.—SECTION OF BRICK LINING.

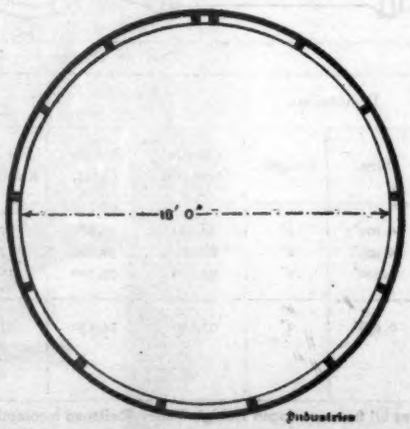


FIG. 4.—SECTION OF CAST-IRON LINING.

about 4 ft. × 18 in., except at the top of the tunnels, where smaller pieces about 9 in. × 18 in. will be introduced.

Each segment will have a flange all round the inside 6 in. deep, measured from the outside of the body of the plate. The body of each segment will be 1 in. thick, and the flanges 1½ in. thick. The segments will be joined together with ¾-in. bolts about 9 in. apart, leaving a space of about ⅛ in. between the flanges for wedging up with soft wood packing, and thus securing a perfectly water-tight joint. The passenger tunnel will be constructed throughout of cast-iron segments, and will have flat stairs at each end in gradients of one in three, thus obviating the necessity of hoists.

As regards the materials used in the undertaking, the bricks are specified 9 in. × 4½ in. × 3½ in., with usual requirements as to soundness, shape, and thorough burning, saturation in water previous to use being likewise required. The mortar is specified to be of the best Portland cement and clean sharp sand, in proportions of one to three. The Portland cement is required to be extremely fine, and weigh not less than 112 lbs. to the imperial bushel; samples of it to bear a tensile load of not less than 350 lbs. per square inch of section after seven days' immersion in water. All exposed joints of the brickwork are specified to be neatly pointed and drawn in with a ¼-in. key. The concrete is composed of one part of Portland cement (of the same quality as above), one part of clean sharp sand, and five parts of hard stones or bricks broken to pass through a 2-in. ring. The cast-iron work, made of tough Scotch gray iron, is required to bear a tensile stress of 6½ tons per sq. in. of section before fracture and 2½ tons per sq. in. without loss of elasticity, while a bar 1 in. sq. is to sustain a weight of 7 cwt. at the center of a 3-ft. span. All castings are to be sound, clean, free from cinder, air-holes, twists, and all similar blemishes, and to have a skin perfectly smooth and uniform. The malleable iron is specified not to fracture with a less load than 22 tons per sq. in. of sectional area, with an elongation before fracture of not less than 8 per cent. on a length of 10 in. The iron work is dipped in a mixture of boiling tar and pitch, and all exposed parts receive two coats of Carson's patent anti-corrosive white paint.

The work of riveting up the second shield at the bottom of the shaft on the south side will shortly be commenced, while the erection of air-compressing plant and boiler power for the same on the surface is completed.

THE UNITED STATES NAVY.

THE Navy Department has devoted considerable attention recently to the armor for the new ships, and experiments have continued at the new Indian Head proving ground on the Potomac. In the latest trials two targets were made up, one composed of two 1½-in. plain steel plates, and the other of two plates of the same thickness of nickel steel. They were intended to represent a protective deck, and in these trials were placed almost horizontally, presenting an angle of 2° only to the line of fire. The gun used was a 6-in. breech-loading rifle with a 100-lbs. armor-piercing projectile. With a muzzle velocity of 1,780 foot-seconds, the shots passed through both of the plain steel plates, through 2 ft. of oak backing and 8 ft. of earth. With the nickel-steel plates, on the other hand, the shot had a velocity of 1,873 foot-seconds, and its only effects on the target were a small crack 5 in. long in one plate and an indentation from 3 to 5 in. deep. The shot itself was broken in pieces.

The tests of nickel-steel and of the Harvey process have been so successful that the Navy Department has given an order for nickel-steel armor plates for the 13-in. side armor for the coast defense ship *Monterey*, now building in San Francisco. The turret armor for this ship, which is now being made at Bethlehem, and which is of plain steel, will also be treated by the Harvey process.

The new 6-in. rifle built at the Washington Navy Yard has given some excellent results under test. This is the longest 6-in. gun yet made by the Navy, having a length of 40 calibers. With this gun a velocity of 2,180 foot-seconds has been attained without exceeding an internal pressure of 15 tons to the square inch.

Trials have been made of the first samples of smokeless powder for the Navy Department with very good success. These trials were made with 6-pounder and 3-pounder rapid-fire guns. The powder has been made by Professor Munroe, chemist at the torpedo station at Newport, and its composition has not been made public.

The Washington Ordnance Shop has completed the first of the 4-in. and 5-in. rapid-fire guns. The 4-in. gun is designed for a muzzle velocity of 2,000 ft., with a projectile weighing 33 lbs. and a charge of 12 to 14 lbs. This gun has a bore of 128 in. There are 30 grooves in the rifling. The total length of the piece is 13.7 ft., and its weight 1½ tons. The 5-in. gun weighs 3.1 tons, and is 17.4 ft. long over all. It is expected to attain a muzzle velocity of 2,250 ft., with a shot weighing 168 lbs. and a charge of 30 lbs. of powder. The mount for these guns is that designed by Lieutenant Fletcher, and is of the same type which has been used for similar rapid-fire guns.

NEW SHIPS.

The next ship to be launched for the Navy will probably be Cruiser No. 9, which has been named *North Point*, and which is under construction at the Columbian Iron Works, in Baltimore. This ship and No. 10, which is at the same yard, are 257 ft. long, 37 ft. beam, 14 ft. 6 in. mean draft and 2,000 tons displacement. They are to have a speed of 18 knots, will be armed with rapid-fire guns, and will doubtless be very useful ships.

Bids were opened August 26 for the construction of torpedo-boat No. 2, a description of which has already been published. This is to have a maximum speed of 25 knots an hour guaranteed by the contractor. Two bids only were received. The Cowles Engineering Company, of Brooklyn, N. Y., offered to build the ship for $117,490, while the Iowa Iron Works, of Dubuque, Ia., presented a bid for $113,500. It is probable that the contract will be awarded to the last-named company, as a report has been made to the Navy Department, after inspection, that it possesses sufficient facilities for executing the contract properly, and within the required time.

A LONG COMPARATOR.

BY PROFESSOR J. HOWARD GORE.

WE are a nation of boasters, addicted to a chronic use of superlative adjectives. It is our pleasure to speak of the tallest monument, the longest bridge, the greatest lakes and rivers, etc., and we reach our climax of joy when we add "in the world." After the perusal of this article some may feel that there is now one thing more to be placed in the superlative class—the longest *Comparator* in the world. The Coast Survey several years ago laid out and marked near Washington a kilometer which was to have the name "standard kilometer," but it has never been standardized. Likewise the Prussian Geodetic Institute has projected a kilometer near its new building at Potsdam, but the expectation is that this will be regarded merely as a test base where various forms of apparatus can be tried. But the hectometer at the Holton base-line is in the strictest sense of the word a comparator, and one of the highest degree of merit.

At each end of the stretch heavy rectangular stone pillars were set on top of a broad foundation which were placed on a base of cement. The tops of these stones are even with the surface of the ground, and are provided with brass bolts whose upper ends terminate in carefully turned hemispheres. These bolts are firmly imbedded in the stones, and project far enough above the stones to admit of caps, which are screwed over the hemispheres for their protection. These spheres are not marked, but serve as the support of what is called a cut-off—such as was used by the Lake Survey with such marked success. In the main a cut-off consists of a steel tube, the lower end furnished with a socket which fits the brass hemisphere just mentioned; the other end carries a level and scale fixed at right angles to its axis. This scale is accurately divided into millimeters, the zero point being in the axis of the steel tube. It is apparent that when the level, in adjustment, indicates horizontality, the zero point of the scale is

directly over the center of the sphere on which the tube rests. If the graduation of the scale is eccentric, the error is eliminated by reversing the scale—that is, by turning the tube through 180° in azimuth. The tube has a rack so constructed that the upper end can be thrust upward, thus carrying the scale into the focus of a reading microscope. With the ends of the comparator in the axes of the cut-offs —one at each end—the question remains, how to determine the *exact* distance between these verticals. A double track resting on broad stringers spiked to 4-in. × 12-in. posts well set in the ground extends from one end of the comparator to the other, with the terminal stones approximately midway between the two tracks, but completely isolated from them. Opposite these stones, and near, but not touching the track, are 6-in. × 6-in. posts projecting about 19 in. above the track; similar posts are likewise placed in the line of these two along the whole length at a distance of 5 meters apart. They are supports for reading microscopes.

The only feature that remains to be described is the bar and its application to the comparator. The bar is of steel, with silver plugs set in its neutral axis, on whose upper surfaces a fine line on each marks the terminus of the 5 meters. This bar rests in the vertical of its greater transverse section in a steel Y-shaped trough. The trough itself is carried on two trucks of three wheels each so distributed as to run smoothly on the iron rails of the track already described. By means of screws the supports of the trough can be moved transversely in the direction of its length, and up or down.

Before leaving Washington the bar was most carefully compared with the committee's meter, both being surrounded by ice, so that the distance between the lines on the plugs is known at this temperature. In obtaining the length of the comparator, the operation in general is as follows: The cut-off is placed in position and leveled, a reading microscope provided with a micrometer reading to tenths of a mikron, is pointed on a convenient division of the scale, and read both before and after reversal, together with contemporaneous level readings; the cut-off is removed, and the carriage bearing the bar surrounded by fine ice is rolled along until its rear end is brought under and in the focus of the microscope just used, a pointing is made on the terminal line within the nearest revolution of the micrometer and the division recorded; while this is being done a similar microscope is read on the forward end of the bar. The bar is then wheeled along until the rear end occupies a position with respect to the second microscope that it just had with respect to the first, and the microscope vacated is carried forward and clamped to a post ready for future use; with four of these microscopes there is ample time for one to become steady before being used. From this it is seen that each forward microscope is made to fix and hold the exact point reached by a length of the bar. When the other end of the comparator is reached, an operation approximately the converse of the one first described is performed, that is, the pointing is first made on the bar, and that point determined with respect to the center of the sphere by readings on the cut-off. These operations, somewhat complex in their description, are, however, so readily performed that the twenty applications necessary for measuring the hectometer can be made in about half an hour.

THE HOLTON COMPARATOR.

SHOWING APPLICATION OF SECONDARY BARS TO THE COMPARATOR.

Every possible care has been taken to secure stability in the track, stones, and microscopes, and by way of precaution the walks on both sides of the track are covered with sawdust, and the whole is roofed in and enclosed on one side and both ends. Its east and west direction protects all parts of the apparatus from sudden changes of temperature due to sunshine and clouds.

From a number of measurements of the comparator the probable error of its length has been found to be equivalent to one part in five millions, which is approximately the same as the error of comparing the five-meter bar with the prototype, so that we may say the length of the comparator is absolutely known in terms of the international standard.

On this comparator the apparatus used in measuring the Holton base has been tested with most satisfactory results. Likewise the tapes to be employed in the same work have had their lengths determined here, and also their coefficients of expansion.

The discussion of the observations made at Holton will contain most interesting facts regarding the behavior of

metals at different temperatures, the effects of tension on length, and the possibilities of tapes for base measuring.

The accompanying illustration, from a photograph, shows the application of secondary bars to the comparator. From this and the description above, the method of operation can be readily understood.

THE WOOTTEN LOCOMOTIVE.

THE report of the Committee on Science and the Arts of the Franklin Institute, awarding the John Scott premium and medal to Mr. John E. Wootten, for his invention of a locomotive boiler, has been recently published in the *Journal* of the Franklin Institute, and to it we are indebted for the following account, which includes the substance of the report:

The distinguishing features of these engines, as compared with others, is a much greater breadth of furnace and larger area of grate, with a less depth of fuel thereon, a change in the location of the cab from the rear of the engine and at the sides of the fire-box to a position above the furnace, in some instances, and in others on each side of the waist of the boiler immediately in front of the fire-box, the steam-dome being located in the cab.

The construction of frames, driving-wheels, cylinders and steam-chests is not strikingly different from other well-known and usual types of engines.

This engine has been gradually developed into its present form; at the outset, a demand, constantly increasing, for cheaper freights and diminished expense for motive-power in drawing trains, compelled the use of trains of greater capacity, so as to reduce the cost of wages relatively to the tonnage hauled. This necessitated more powerful engines; and while it was not difficult to increase the cylinder capacity or piston displacement of the engines, the limit of the boiler to supply adequate steam to such engines was soon reached.

The gauge of the railroad appeared to limit the width of the boilers admissible, the frames could not be spread any further apart, and under the practice of placing the furnace of the boiler between the frames, the only increase of grate surface practicable was in the direction of length. This rendered firing more difficult, and a deep bed of fuel was required to maintain steam pressure, the draft of air to maintain combustion demanded greater pressure on the exhaust, which could only be enforced by contracting the nozzle of the exhaust pipe and imposing a pressure upon the steam pistons during the return strokes. This, in view of the large piston surface recently coming into vogue, especially in compound locomotives, means a serious waste of force.

In addition to the above incentives to improvement, immense quantities of perfectly good coal, in dust and small grains, was steadily accumulating around every mine, and while its value, when burned in a well-adapted furnace in a stationary engine, was a matter of daily demonstration, no long furnace or deep bed of such fuel was able to burn it upon a railroad locomotive; and, moreover, a deep fire of such fuel would not burn because the draft could not be forced through its entire surface without much of the fuel being carried beyond reach with the then generally adopted furnaces.

The solution of this difficulty was found in an increased breadth of furnace, grate and fire-box to accommodate it. Space to contain such boilers without interfering with the driving-wheels was procured by placing the boiler above the driving-wheels and frames, which were protected from ashes by a hopper-shaped ash-pit.

The boiler then had broad expanses of nearly flat metallic external as well as internal surfaces, having cross-seams exposed to high internal pressure and required to be securely stayed or braced. The form of the plates presented oblique opposing surfaces, and stay-bolts diagonal to such surfaces were applied to hold them together.

The oblique strain upon such stays and the oblique intersections of the stays and plates were subjected to shearing or diagonal strains, and the failure of such stays by breaking close to the plates became a conspicuous objection to such structures.

The remedy was found in changing the form of the furnace and the portion of the external shell of the boiler enclosing it so as to bring nearly parallel surfaces, formed of large plates without cross-seams, opposed to each other. After this the stays uniting them were subjected only to direct tensile strains, and withstood them.

The fuel in such broad expanses of surface developed volumes of combustible gas, which burned with best effect when in large body or volume, but only imperfectly when subdivided by entering the flue tubes; so a combustion chamber was added.

The volume of draft usual with large fuel when applied to fine or pulverulent fuel on a small grate surface, lifts and carries much of it mechanically from the furnace, but in the broad expanses of grate furnished in this boiler, the same volume passes through at a lower velocity and with less pressure, so that instead of sweeping particles of fuel through the tubes with the products of combustion, the fine ash only appears to pass and deposit in a flocculent state in the smoke-box and chimney.

The changes in form of the boiler, which we have thus far noted, are with reference to the combustion of fuel and generation of heat and durability of the boiler.

From experience it appeared desirable to place as much of the weight of the boiler as practicable lower down.

This was effected by the partition or bridge, excluding the fuel from the combustion chamber, in the shape of a dam, with the flue tubes and waist lower down in relation to the grate surface.

The combined effect of these improvements can best be understood by the report of the engine as worked upon the roads.

A sufficient proportion of the weight of the engine is placed upon the front truck wheels, serving to guide it securely upon the rails, while as large a proportion as is practicable is utilized in compelling adhesion between the driving-wheels and the rails for purposes of propulsion.

A capacity for burning fuel, impracticable in furnaces of small grate area and large depth of fire-bed, and an economy in quantity as well as quality of fuel required, ensued.

The several stages of improvement are set forth in the letters-patent, and a brief notice of their features is here briefly stated in chronological order.

In letters-patent 192,725, of July 3, 1877, the hopper-shaped ash-pit and fire-box extending sidewise over the rear driving-wheels of one engine with six drivers and four truck wheels is shown, the combustion chamber being over the middle driving-wheel axle, and included in a tapering part of the boiler uniting the fire-box portion with the cylindrical waist. The claim of this patent is for a fire-box wider than the distance between the wheels, and for the combustion chamber in combination with a bridge wall.

In letters-patent No. 254,581, of March 7, 1882, the ash-pit is in the form of two rectangular funnels or hoppers, the grate is inclined from rear downwardly to the front, a flat crown-sheet is used, stayed with parallel vertical stays to the outer curved shell, and the proportion of the combustion chamber in length to the furnace chamber is reduced.

In letters-patent 291,120, dated January 1, 1884, the forward part of the grate immediately in the rear of the bridge wall and across the entire width of the fire-box is covered with fire-brick to receive small particles of fuel which the draft through the grate would otherwise sweep over the bridge wall.

Patent No. 352,215, of November 9, 1886, shows an improved form of bridge wall which practically separates a combustion chamber within the fire-box from the fuel supporting space on the grate.

Patent No. 354,370, of December 14, 1886, is for a construction of boiler in which the rearward flue-sheet of the furnace is without perforations, and acts as a bridge wall dispensing with the separate bridge walls in the preceding forms of this boiler.

Patent No. 361,661, of April 19, 1887, to J. F. Wootten and J. Snowden Bell, is for a form of this boiler in which

a central partition or water-wall is introduced in the furnace, making in effect two furnaces, with a bridge wall between the furnaces and the combustion chamber and flue.

This construction offers the advantages of alternate firing, so that the gases from the fresh fuel in one furnace can meet the intensely heated flames and products of combustion from the other furnace, and produce a better combustion.

The effect of these improvements, which it will be seen

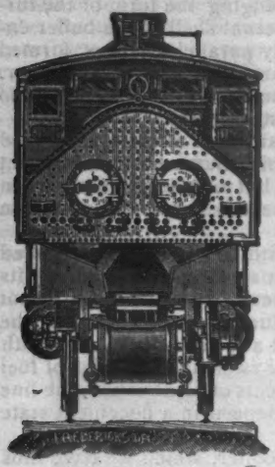


Fig. 2.

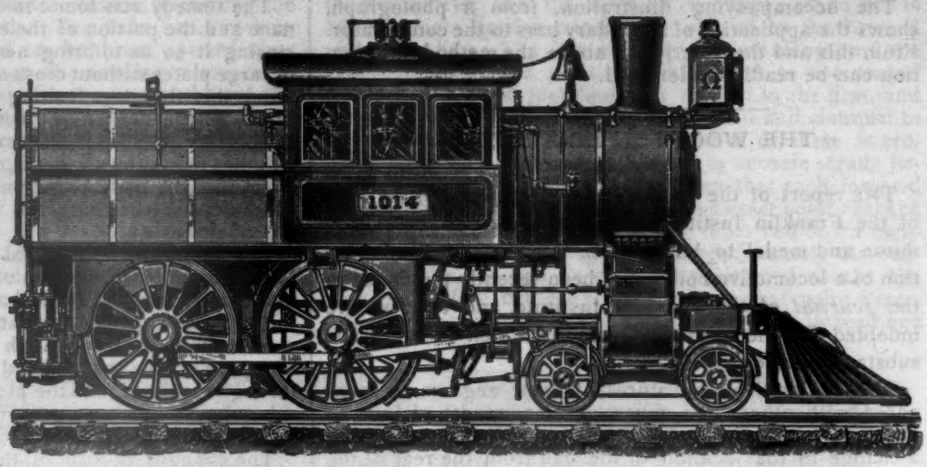
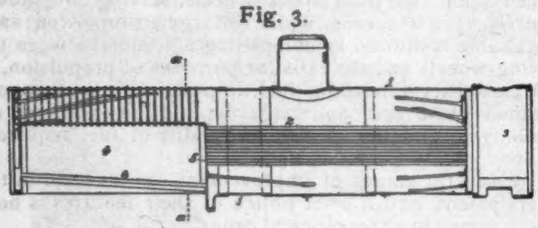
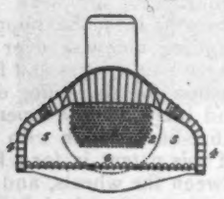


Fig. 1.

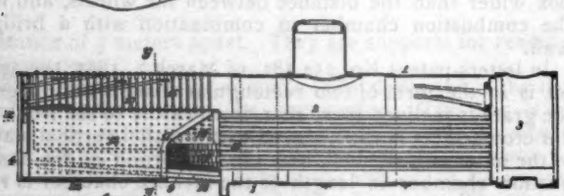
LOCOMOTIVE WITH WOOTTEN BOILER.

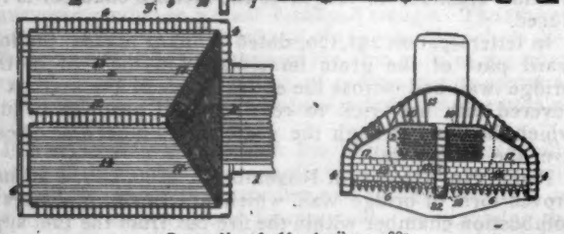
Fig. 3.





Patent No. 354,370, December 14, 1886.





Patent No. 361,661, April 19, 1887.

Fig. 4.

are in a continuous line of gradual development, are to produce a most efficient and serviceable boiler, capable of economically burning cheap grades of fuel inadmissible in other kinds of locomotive boilers.

In support of their conclusions, the Committee quote from the report of tests made by Dr. C. M. Cresson, of a Wootten boiler and an ordinary locomotive boiler burning several kinds of fuel. The results of these tests may be summed up briefly as follows, the table giving the percentage of the total heat units in the fuel used actually utilized in each case:

Class of Locomotive.	Kind of Coal.	Per cent. of total heat utilized.	
		Wootten Boiler.	Ordinary Boiler.
Consolidation freight...	Anthracite, waste.	69.4	....
Passenger...	Anthracite, marketable.	65.5	50.0
Consolidation freight...	Bituminous, waste.	64.3	....
Consolidation freight...	Bituminous, marketable.	69.4	55.2
Passenger.....	Bituminous, marketable.	68.3	54.0
Consolidation freight..	Lignite, 20 per cent. water.	42.1	....

The data from which the work done by these fuels is derived were obtained from the results of continuous daily operations, of such magnitude as to remove them from the category of experiment and place them upon the footing of practical operations.

The award of the Committee was therefore made by the excellent results shown by this invention under tests, fully confirmed by several years of practical use.

The illustrations given herewith show, in figs. 1 and 2, an elevation and rear view of a locomotive with Wootten boiler; in figs. 3 and 4, respectively, the patents No. 354,370 and No. 361,661, as described above.

THE FOWLER TUBULAR BOILER.

THE accompanying illustration, from *Industries*, shows a boiler devised by W. H. Fowler, of Manchester, England. Fig. 1 is a vertical section and fig. 2 a horizontal section.

The inventor claims for this boiler that it is a quick steam raiser, easy of access for cleaning and repairs, and simple in construction. Referring to fig. 1 it will be seen that the fire-box is conical in section, and is riveted at the upper end to a plain cylinder, divided midway into two portions by a fire-clay partition carried on a ring of angle iron supported by brackets. The flame and heated gases, after passing through the lower set of tubes into the smoke-box, pass thence through the upper tubes to the combustion chamber, which is in direct communication with the uptake. It will be seen from the engravings that there is a complete absence of cross water pipes or other

obstructions in the fire-box, and also that there is no awkward flanging. The circular form is adhered to throughout, and the annular arrangement of parts permits easy inspection. The fire-box being circular, an easily made flange joint is used for uniting the ring seams. Where

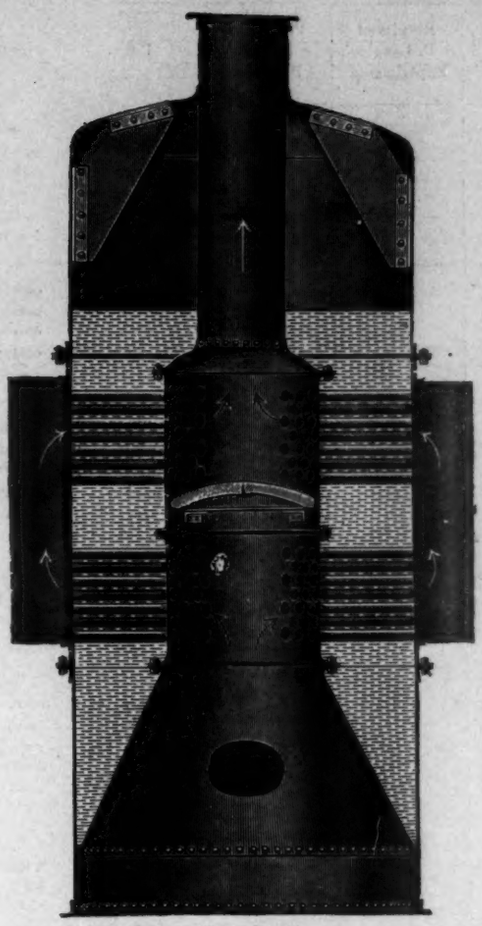


FIG. 1.—VERTICAL SECTION.

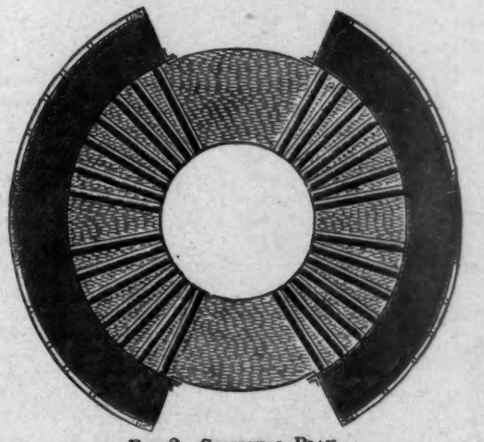


FIG. 2.—SECTIONAL PLAN.

THE FOWLER BOILER.

necessary, the boiler can be divided into three sections for convenience in transportation, and the two bolted joints can easily be made.

The construction can be modified for small boilers, so that the smoke-tubes can discharge directly into an external smoke-box connected with the uptake, instead of being returned to a central uptake, as in the boiler shown in the illustration.

PROGRESS IN FLYING MACHINES.

BY O. CHANUTE, C.E.

HAVING, in June, 1890, delivered a lecture, since published in the RAILROAD AND ENGINEERING JOURNAL, on the general subject of "Aerial Navigation," in which a sketch was given of what has been accomplished with balloons, I propose in the present paper to treat of Flying Machines proper—that is to say, of forms of apparatus heavier than the air which they displace; deriving their support from and progressing through the air, like the birds, by purely dynamical means.

It is intended to give sketches of many machines, and to attempt to criticise them.

We know comparatively so little of the laws and principles which govern air resistances and reactions, and the subject will be so novel to most readers, that it would be difficult to follow the more rational plan of first laying down the general principles, to serve as a basis for discussing past attempts to effect artificial flight. The course will therefore be adopted of first stating a few general considerations and laws, and of postponing the statement of others until the discussion of some machines and past failures permits of showing at once the application of the principles.

The first inquiry in the mind of the reader will probably be as to whether we know just how birds fly and what power they consume. The answer must, unfortunately, be that we as yet know very little about it. Here is a phenomenon going on daily under our eyes, and it has not been reduced to the sway of mathematical law.

There has been controversy not only about the power required, but about the principle or method in which support is derived. The earlier idea, now abandoned, so far as large birds are concerned, was that when they flapped their wings downward they produced thereby a reacting air pressure wholly equal to their weight, and so obtained their support. This is known as the "orthogonal theory," and has been disproved by calculations of the velocity and resulting pressures of the wing beats of large birds, and by the more recent labors of Professor Marey. It seems likely that the smaller birds, who, as will be explained hereafter, are probably stronger in proportion to their weight than the larger birds, possess the power of delivering blows upon the air equal to a supporting reaction. Such may be the case in the hovering of the hummingbird and the rising vertically of the sparrow; but the latter exertion is evidently severe, and cannot be long continued.

Mr. Drzeweicki has shown that a buzzard, beating his wings 2½ times a second, with an amplitude of 120°, could only obtain, according to accepted formulæ of air pressures, a sustaining orthogonal reaction of 0.40 pounds or about $\frac{1}{10}$ of his weight, while if his wings are considered as inclined planes, progressing horizontally at a speed of 45 miles per hour, a sustaining reaction is easily figured out.

It seems quite certain that large birds cannot practice orthogonal flight, and that they derive their support mainly if not wholly from the upward reaction or vertical component of the normal air pressure due to their speed. That they are living Aeroplanes, under whose inclined wings their velocity creates a pressure which is normal to the surface. This is confirmed by the great difficulty which they experience in getting under way. They run against the wind before springing into the air, or preferably drop down from a perch in order to gain that velocity without which they cannot obtain support from the air. Thus the surfaces of their wings act as aeroplanes as well as propellers, the latter action being produced by the direction of the stroke and the bending upward of the rear flexible portion of the feathers.

Bird flight may be considered as comprising three phases:

1. Starting, during which great exertion must be made, unless gravity can be utilized.

2. Sailing, or flight proper, during which the bird exerts his normal force, or makes use of that of the wind, as will be more particularly explained hereafter.

3. Stopping, in which great exertion may again be re-

quired, if the headway is to be rapidly stopped, or in which the retarding force of gravity may be brought to do the work by simply rising to a perch.

Artificial flying machines will certainly have to conform to these three phases of flight, by providing methods of starting and stopping in addition to the means for performing the act of flight proper.

Birds perform all their manœuvers by regulating the intensity of their action, and by changing the angles at which they attack the air. Hence the important thing for us to know is to ascertain what pressure exists under a wing or, to simplify the question, under a plane surface, when it meets the air at a certain velocity and with a certain angle of incidence.

This has been, until the recent publication of Professor Langley's most important labors, a subject of uncertainty, which uncertainty he has done much to remove. We had had glimpses of the law; but notwithstanding very many experiments by physicists, its numerical values were a subject of doubt and controversy among the few who gave any attention to the subject. It was the missing link, which rendered nearly unavailable the little that was known in other directions.

By the law of fluid reactions all air pressures are "normal," or exerted perpendicularly to the surfaces against which they bear; now the question was: What is the relation between the pressure of a current of air of known velocity against a thin plane surface placed at right angles thereto, and the normal pressure of that same current against the same plane, if the latter be inclined to the current at an angle of incidence less than 90 degrees?

Newton impliedly gave a solution; but experiments long ago proved it to be wrong, although it is still taught in the schools and given in formulas in engineering reference books. He assumed, plausibly enough, that the proportional normal pressure was in the ratio of the sine of the angle of incidence, and when experiment showed this to be erroneous, other formulas were proposed, the following being a few of those which have been wrangled over:

Calling a the angle, and P the pressure on the inclined surface, while P' is that upon the right-angled surface, the following were assumed to represent the relation:

$$P = P' \sin a \qquad P = P' \sin^2 a$$

$$P = P' \sin^3 a \qquad P = P' (\sin a)^{1.84 \cos a}$$

$$P = P' \frac{2 \sin a}{1 + \sin^2 a} \qquad P = 2 P' \sin a$$

Indeed, the field seemed so open in this direction that only two years ago I ventured to propose a formula of my own, which I subsequently concluded to be erroneous; but the question seems now to be set at rest for the present by the experiments of Professor Langley, who proposes no formula of his own, but who shows that his results approximate very closely to the formula of Duchemin:

$$P = P' \frac{2 \sin a}{1 + \sin^2 a}$$

I had already independently reached a conclusion quite similar. Finding that my formula was incorrect, I had a chart plotted, on which were delineated all the experiments on inclined surfaces which I could learn about—those of Hutton, Vince, Thibault, Duchemin, De Louvrié, Skye, the British Aeronautical Society, and W. H. Dines; and on this chart I also had plotted the curves of the various formulas. The whole exhibited great discrepancies, yet by patient analysis various probable sources of error were eliminated, and the conclusion was reached that the formula last given, which I have seen variously attributed to Bossut or to Duchemin, was probably correct.

From this formula I had computed for my own use the accompanying table of normal pressures; and as it seems to be quite confirmed by Professor Langley's experiments, and seems to promise to be of great use, I now venture to publish it.

Once the normal pressure is known at a particular angle of incidence, its static components in different directions can be obtained by the laws governing the resolutions of forces. This was shown, as early as 1809, by Sir George Cayley, in the following demonstration, in which he ingeniously evades the then prevailing confusion about the

Approximate Percentages of Normal Pressure. Derived from Chart of Experiments and Theories. Calculated by Bossut's or Duchemin's Formula.

$$P = P' \frac{2 \sin a}{1 + \sin^2 a}$$

Deg. of Angle.	Results of S. P. Langley's Experiments.	Proportion Normal Pressure.	Lift.	Drift.
1		0.035	0.035	0.000611
1½		0.052	0.052	0.00136
2		0.070	0.070	0.00244
3		0.104	0.104	0.00543
4		0.139	0.139	0.0097
5	0.15	0.174	0.173	0.0152
6		0.207	0.206	0.0217
7		0.240	0.238	0.0293
8		0.273	0.270	0.0381
9		0.305	0.300	0.0477
10	0.30	0.337	0.332	0.0585
11		0.369	0.362	0.0702
12		0.398	0.390	0.0828
13		0.431	0.419	0.0971
14		0.457	0.443	0.1155
15	0.46	0.486	0.468	0.124
16		0.512	0.492	0.141
17		0.538	0.515	0.157
18		0.565	0.538	0.172
19		0.589	0.556	0.192
20	0.60	0.613	0.575	0.210
21		0.637	0.594	0.228
22		0.657	0.608	0.246
23		0.678	0.623	0.264
24		0.700	0.639	0.286
25	0.71	0.718	0.650	0.304
26		0.737	0.662	0.323
27		0.752	0.670	0.342
28		0.771	0.681	0.362
29		0.786	0.686	0.382
30	0.78	0.800	0.693	0.400
31		0.815	0.698	0.421
32		0.828	0.702	0.439
33		0.843	0.706	0.459
34		0.853	0.707	0 478
35	0.84	0.867	0.708	0.498
36		0.878	0.709	0.516
37		0.885	0.709	0.532
38		0.894	0.705	0.551
39		0.902	0.701	0.569
40	0.89	0.910	0.697	0.586
41		0.918	0.693	0.602
42		0.926	0.688	0.619
43		0.934	0.683	0.638
44		0.941	0.676	0.654
45	0.93	0.945	0.666	0.666

"law of the angle" by starting with the weight of the bird instead of its wing surface and velocity. He says:

When large birds, that have a considerable extent of wing compared with their weight, have acquired their full velocity, it may frequently be observed that they extend their wings, and, without waving them, continue to skim for some time in a horizontal path.

Fig. 1 represents a bird in this act. Let $A\ B$ be a section of the plane of both wings, opposing the horizontal current of air (created by its own motion), which may be represented by the line $C\ D$, and is the measure of the velocity of the bird. The angle $B\ D\ C$ can be increased at the will of the bird, and to preserve a perfectly horizontal path, without the wing being

waved, must continually be increased in a complete ratio (useless at present to enter into), till the motion is stopped altogether; but at one given time the position of the wings may be truly represented by the angle *B D C*. Draw *D E* perpendicular to the plane of the wings, produce the line *C D* as far as required, and from the point *E*, assumed at pleasure in the line *D E*, let fall *E F* perpendicular to *D F*; then *D E* will repre-

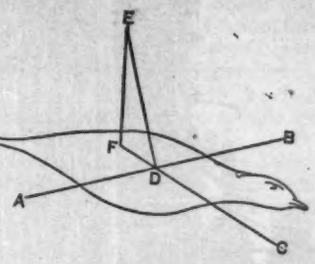


Fig. 1.

sent the whole force of the air under the wing—*i.e.*, normal pressure, which being resolved into the two forces *E F* and *F D*, the former represents the force that sustains the weight of the bird, and the latter the retarding force by which the velocity of the motion producing the current *C D* will be continually diminished; *E F* is always a known quantity, being equal to the weight of the bird, and hence *F D* is also known, as it will bear the same proportion to the weight of the bird as the *sine* of the angle *B D C* bears to its *cosine*, the angles *D E F* and *B D C* being equal.

In the table herewith given, the first column shows the degree of the angle of incidence; the second the result of Professor Langley's experiments; the third the proportion or percentage which the normal pressure at that angle bears to the pressure at the same velocity of the same plane at right angles to the current; while the fifth and sixth columns show the resolutions of this normal pressure, being the force which sustains the weight of the bird vertically as against gravity, which is here termed the "Lift;" and the retarding force against horizontal motion, which is here termed the "Drift." They are calculated by multiplying the normal pressure by the *sine* and by the *cosine* of the angle.

In order to obtain the aggregate normal pressure, or the lift and the drift, upon any thin plane surface, it is simply necessary to multiply its area by the pressures per square foot, which are given (approximately) in the ordinary tables of wind velocities, and this again by the percentages given in the table.

The angles are only given up to 45°, as more than this would be useless to the general reader; and it will be noted that there is an angle of maximum uplift at about 36°. This results from the fact that the normal pressure is continually increasing, while the *cosine* of the angle is continually diminishing, but not equally, so that their product reaches a maximum, as stated. This is confirmed by the results of Professor Langley's experiments, as recorded on page 58 of his "Experiments in Aerodynamics."

It should be borne in mind that the table only purports to apply to thin planes one foot square, and hence is given as containing only approximate percentages of normal pressures. For other shaped planes, for curved surfaces, and for solids the percentages may be different, because a great many anomalies have been found in experimenting upon air resistances, and we yet know painfully little about them.

For instance, the following may be mentioned:

1. For high velocities, such as those of projectiles, the resistances do not vary as the square of the speed, as assumed in ordinary tables; they more nearly approach the cube of the velocity.

2. If a thin plane be exposed to a current of air, at right angles thereto, the pressure on the plane is not uniform over all its surface, but is greatest at the center.

3. Plane surfaces of equal areas but of different shapes (square, oblong, triangular, etc.) are found to receive slightly different pressures at the same speed. Moreover, the average pressure per square foot varies with mere variation of size on the same shaped planes.

4. The pressure upon an inclined elongated surface will vary for the same speed, whether it be exposed longitudinally or transversely to the current.

5. Holes may be cut in thin planes without reducing the aggregate pressure in proportion to the surface cut away. Moreover, the aggregate pressure may be made to vary by simply changing the position of the holes.

6. Inclined planes may be superposed without diminishing the sum of their separate individual pressures, provided they are properly spaced with regard to the angle of incidence. If too close, they will interfere with each other, but the amount of such interference will vary with the speed.

7. Perfectly horizontal planes, free to fall, have their time of falling much retarded if in rapid horizontal translation.

8. The weight remaining the same, the force requisite to sustain *inclined* planes in horizontal motion diminishes instead of increasing, when the velocity is augmented.

9. If the plane be gradually inclined to the current, the point of maximum pressure will move forward toward the front edge as the angle of incidence diminishes. The position as given by Joëssel's law is shown by the formula:

$$C = (0.2 + 0.3 \sin a)\, L,$$

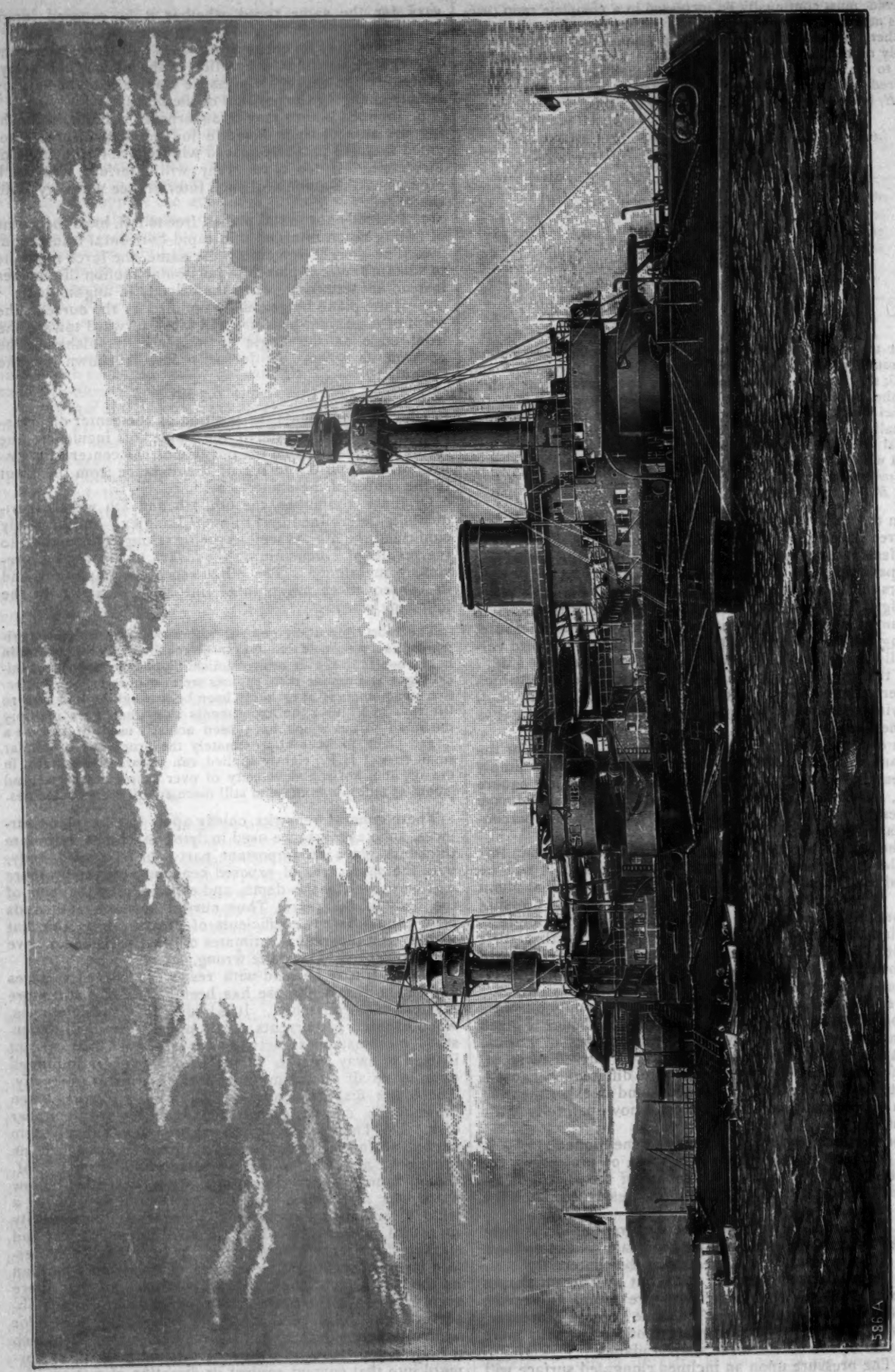
in which *C* represents the position of the center of pressure, *L* the length, and *a* the angle of incidence, the formula indicating that the position of the center of pressure varies from 0.5 to 0.2 of the distance from the front to the center of the plane.

Of these anomalies, the 6th, 7th and 8th were experimentally determined by Professor Langley; and he partly confirmed the 9th, as well as giving strong confirmation to the results of Duchemin on the "law of the angle" previously mentioned. The 8th is especially important, and its consequences are pointed out by Mr. Langley in the following words:

> The most important general inference from these experiments, as a whole, is that, so far as the mere power to sustain heavy bodies in the air by mechanical flight goes, such mechanical flight is possible with engines we now possess, since effective steam-engines have lately been built weighing less than 10 lbs. to 1 H.P., and the experiments show that if we multiply the small planes which have been actually used, or assume a larger plane to have approximately the properties of similar small ones, 1 H.P., rightly applied, can sustain over 200 lbs. in the air, at a horizontal velocity of over 20 meters per second (about 45 miles an hour), and still more at still higher velocities.

These general remarks chiefly apply to thin plane surfaces, such as might be used in flying machines, but mere thickness plays an important part; for in a solid body, with the same area of exposed head surface, the pressure will be varied by the depth, and especially by the form of the body in the rear. Thus curved surfaces and solids have quite different coefficients of pressure from thin flat planes, and theoretical estimates of their resistances have hitherto proved to be quite wrong.

Indeed, it may be said with respect to curved surfaces and solids, that a glimpse has been caught of a still more mysterious phenomenon. It is known that certain shapes, when exposed to currents of air under certain ill-understood circumstances, actually move toward that current instead of away from it. Thus a hollow sphere impinged upon by an air jet will move up toward it instead of away. The lower disk in Professor Willis's apparatus, when blown upon, moves against the current toward the upper disk. Dr. Thomas Young proved, in 1800, that a certain curved surface suspended by a thread approached an impinging air current, instead of receding from it. M. Goupil found, in experimenting, that a suspended hollow shape was first blown out to a horizontal position by a wind of sufficient velocity, and then, when that velocity increased, actually drew into the wind for an instant and slackened the tension on the cord. It is also said that certain forms of windmills wear more on the front stop than on the back stop of their axle of rotation; so that there seems to be a mysterious action, which some French observers, who have been watching birds soar, have, for want of a better term, called their "Aspiration," by which a body acted upon by a current may actually draw forward into that current against its direction of motion.



BATTLE-SHIP "HOCHE" FOR THE FRENCH NAVY.

Thus it is seen that in such complicated matters theory cannot progress in advance of experiment, and the extreme importance of those experiments hitherto tried, or hereafter to be tried by a physicist possessing the ability of Professor Langley, will in part be appreciated.

Science has been awaiting the great physicist, who, like Galileo or Newton, should bring order out of chaos in aerodynamics, and reduce its many anomalies to the rule of harmonious law. It is not impossible that when that law is formulated all the discrepancies and apparent anomalies which now appear, will be found easily explained and accounted for by one simple general cause, which has been hitherto overlooked.

Thus far, Professor Langley seems to have experimented upon plane surfaces only, and to have measured chiefly what has been termed in the table here given the "lift" and the "drift" at various angles. His conclusions therefrom are very important; but the "drift" will not be the sole resistance to be encountered, for the sustaining surfaces of a flying machine must not only have a certain thickness, to give them the necessary strength and rigidity, but there will be friction of air upon them, and there must be a solid body or hull to contain the machinery and the cargo.

Thus the elements of resistance are three in number:

1. The hull resistance.
2. The drift.
3. The skin friction.

Of the skin friction Professor Langley says that it is apparently so small that it may be neglected without material error; and he has given the measure of the "drift" as the result of his experiments.

The head or hull resistance will probably be found to be the chief element which will limit the possible speed of flying machines. It will probably grow as the square of the velocity, thus requiring the power exerted to vary as the cube of the speed, but will be modified by a series of coefficients, due to the shape of the solid body, just as some birds are swifter flyers than others of the same weight, in consequence of their difference in shape.

Hence the power required to drive such a machine can only be approximated at present; but this will be more particularly discussed when treating of the areas of supporting surfaces and speed of birds, for the reader may be impatient to be told something of what has been attempted by man.

Inventors, in their ignorance of the laws of air reactions and resistances, have proposed all sorts of devices for compassing artificial flight and experimented with not a few; so that Mr. E. Dieuaide, of Paris, upon making a study of the subject, published in 1880 an illustrated chart,* in which he delineated the more remarkable machines which had been proposed for aerial navigation without the use of balloons. This chart contains some 53 figures; and from this, as well as from the book of M. Gaston Tissandier on aerial navigation,† which contains much accurate information, the following has been chiefly compiled, in which it will be attempted not only to give an account of what has been proposed, so far as the meager data will permit, but also to critcise the machines with the light of our present knowledge, and to endeavor to point out why they failed. Failures, it is said, are more instructive than successes; and thus far in flying machines there have been nothing but failures.

These various machines, diverse as they are, may roughly be classed under the three following heads, according to the intentions and theories which were held by their authors, as to the most efficacious way of deriving support from the air.

A. Wings and parachutes.
B. Screws to lift and propel.
C. Aeroplanes.

(TO BE CONTINUED.)

* *Tableau d'Aviation.* Représentant tout ce qui a été fait de remarquable sur la navigation Aérienne sans Ballons. Published by the author.

† *La Navigation Aérienne.* Par Gaston Tissandier. Hachette et Cie; octavo, 334 pp.

THE FRENCH BATTLE-SHIP "HOCHE."

THE accompanying engraving, from the London *Engineering*, shows the French battle-ship *Hoche*, lately put into commission. At a first glance the picture shows that the ship is another instance of the propensity of the French naval constructors to pile up barbettes, turrets, casemates and other structures on their ships. Whatever may be said of their strength, this certainly does not add to their appearance.

The *Hoche* is one of the most, if not the most powerful of the battle-ships of the French Navy. Commenced in the French Government Arsenal at Orient in 1880, it was launched in 1886, and fully commissioned in the early part of this year, having been 10½ years in construction. The original design was similar to those of the other new French iron-clads *Marceau*, *Magenta* and *Neptune*, but great alterations have been made in the designs for her upper works during the construction. The hull from the keel to the water-line is constructed of iron, but all that part above water is of mild steel. The *Hoche* is built on the cellular system, and has her forward water-tight compartments filled with cellulose. She has the following principal dimensions: Displacement, 10,581 French or 10,412 English tons; length, 330 ft. at water-line; beam, 66 ft. outside armor; draft, 27 ft. 3 in.; depth, 42 ft. 2 in. The engines are four in number, two driving each of the two propellers. They are of the vertical compound type, and under forced draft indicated 12,000 H.P. on her steam trials, giving a maximum speed of 15.7 knots per hour; they indicated 7,000 H.P. under natural draft. Both engines and boilers were built by contract at the engine works of Indret, and, at a speed of 10 knots per hour, should, with the 600 tons of coal carried, enable the ship to run for a distance of 4,000 knots. The boiler pressure is 85½ lbs. per sq. in.

The *Hoche* is said to carry more artillery than any other French ship, which is probable, seeing that, including the mitrailleuses, her armament consists of nearly 50 pieces.

Two 34-cm. (13.39-in.), 52-ton guns and two 27-cm. (10.63-in.), 28-ton guns form the principal part of the armament. The two former are situated in towers, one forward and one aft, the freeboard having been kept very low for this purpose, while the two 27-cm. guns are placed in barbette towers amidships on sponsons, one on the starboard and one on the port side. In addition to this armament there are fourteen 14-cm. (5.51 in.) guns in the battery and four 14-cm. guns on the spar deck, two forward, firing ahead, and two aft, firing astern. The offensive power of the ship is completed by five tubes firing Whitehead torpedoes, and a powerful ram.

The *Hoche* is protected by an armor belt varying in thickness from 9 in. to 17¾ in., extending the whole length of the ship, and a deck armored with 3⅛-in. plates, while the forward and after turrets of the 34-cm. guns are armored with steel plates 16 in. in thickness. For defense against torpedo attacks the ship is fitted with torpedo defense netting of the Bullivant system.

There are two military masts sufficiently large in diameter to allow of free passage inside them from the upper and spar decks of the ship to either of the two military tops on each mast or to the conning-tower built round the mainmast.

The *Hoche* was commissioned at Brest in the beginning of the present year, and was then sent to Toulon to join the second division of the French Mediterranean squadron, of which she is now the flagship.

THE HOWE TRUSS PROBLEM WITH A CARPENTER'S SQUARE.

BY JOSEPH H. HOWE.

THE solutions of the Howe Truss Problem have become almost innumerable, but most of them are beyond the reach of the ordinary workman. The ideal solution for the bridge carpenter would be one which could be worked out with the square without recourse to analytical computations of any kind.

An admirable method of approximations by Professor Lænas G. Weld, which appeared in the April number of the *Transit*, 1890, furnishes a basis for a simple graphical solution of this problem.

Using the same nomenclature as he employs—viz.: a = depth of panel between chords; b = length of panel from center to center of vertical rods; r = perpendicular side of angle-block; s = base of angle-block; c = width of strut; t = length of strut and x = the angle the axis of strut makes with the vertical rods (see fig. 1), we have, according to his equations,

$$r = c \sin x, \text{ and } s = c \cos x, \text{ but}$$

$$\sin x = \frac{b}{\sqrt{a^2 + b^2}} \text{ approximately, and}$$

$$\cos x = \frac{a}{\sqrt{a^2 + b^2}} \text{ approximately; substituting}$$

$$r = \frac{c\,b}{\sqrt{a^2 + b^2}} \text{ (1) and}$$

$$s = \frac{c\,a}{\sqrt{a^2 + b^2}} \text{ (2) approximately.}$$

In this form the carpenter might *compute* the dimensions of the angle-blocks without being familiar with trigonometric functions; but these expressions may be evaluated graphically, using simply the carpenter's square and a straight-edged board.

Clearing (1) of fractions:

$$c\,b = r\sqrt{a^2 + b^2}, \text{ or writing as a proportion,}$$

$$\sqrt{a^2 + b^2} : b :: c : r \text{ (3).}$$

$\sqrt{a^2 + b^2}$ is the diagonal of rectangle $a\,b$. In the right-angled triangle $M\,O\,N$, fig. 2, in which $N\,O = a$ and $M\,O = b$, $M\,N = \sqrt{a^2 + b^2}$.

On the line $M\,N$, laying off $M\,Z = c$, and drawing $Z\,W$ parallel to $N\,O$, we have: $M\,N : M\,O :: M\,Z : M\,W$, a comparison of which with (3) shows that $M\,W$ is a graphical approximation to r.

In the same manner laying off $N\,P = c$, and drawing $P\,Q$ parallel to $O\,M$,

$$N\,Q = \frac{c\,a}{\sqrt{a^2 + b^2}}, \text{ the first approximation to } s.$$

The distances $M\,O = a$ and $O\,N = b$ may be laid off to some convenient scale, as one inch to the foot, while c is laid off full size; r and s will then be to full-sized scale.

Now subtracting the first result from a and the second from b (using scale of one inch to the foot), forming a rectangle with the remainders and drawing its diagonal, the result is the length t of the strut to the scale of one inch to the foot—$M'\,N'$, fig. 2.

Then using the lessened values of a and b as obtained above in the diagram, and obtaining the values of $M'\,W'$ and $Q'\,N'$ exactly as $M\,W$ and $Q\,N$ were obtained, we have the second approximation for r and s, which will be found to be sufficiently exact, although the operation may be repeated as many times as desired.

Taking Professor Weld's example, in which a = 8 ft. 4½ in., b = 6 ft. 6 in. and c = 7½ in., a scale graduated to $\frac{1}{8}$ in. gives, for the first approximation, r = 0.383 ft., s = 0.494 ft., t = 10.000 ft.; and for the second approximation, r = 0.375 ft., s = 0.500 ft., t = 10.000 ft., the latter being the exact values; the results are reduced to *feet* for purposes of comparison.

The length of strut given by the line $M'\,N'$ is liable to a slight error, owing to the reduction of the scale; but nothing would be gained by a second approximation.

In the drafting room, where finer instruments are at hand, the method furnishes a very accurate check upon analytical computations.

To obtain the length of strut accurately on the timber, lay off $M'\,K = 1$ ft. (fig. 2) and draw $K\,L$ perpendicular to $M\,O$, meeting $M'\,N'$ or $M'\,N'$ produced. Using $M'\,L$ as a unit of measure as many times as the panel is feet long, the required length is obtained. A fraction of a foot may of course be added when it occurs by making

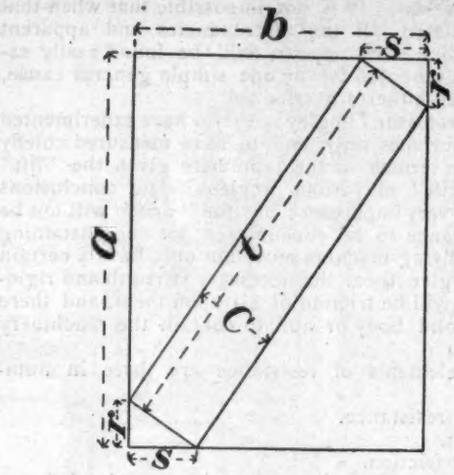


Fig. 1.

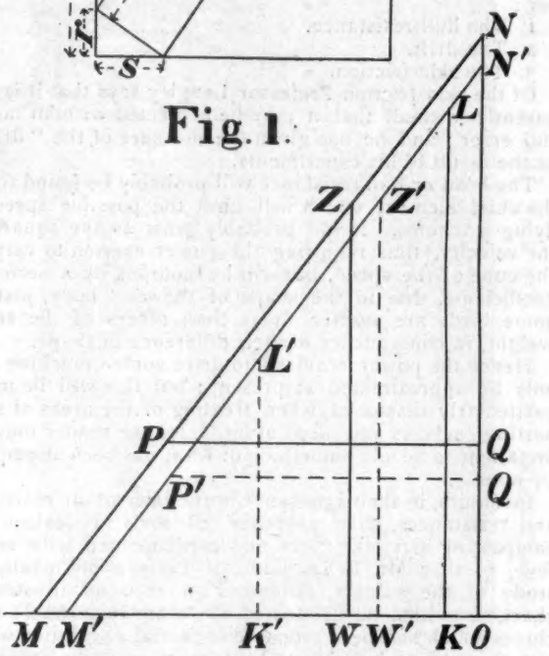


Fig. 2.

$M'\,K'$ = the fractional distance, and adding $M'\,L'$ to the length already obtained.

For the bridge carpenter we would formulate the following:

RULE.

Using a scale of 1 in. equal to 1 ft., lay off the length of panel between the centers of vertical rods upon the straight edge of a board, $M\,O$.

From one end, O, of the distance $M\,O$ draw a line at right angles to $M\,O$; lay off on this line to a scale of one inch to the foot the depth of the panel between the chords $O\,N$.

Connect M and N by a straight line. Beginning at the point M, lay off on the line $N\,M$ the distance $M\,Z$ = the *actual* width of the brace to be used, and draw $Z\,W$ parallel to $N\,O$. From the point N on the line $M\,N$ lay off the distance $N\,P$ = the actual width of the brace, and consequently equal to $M\,Z$. Draw $P\,Q$ parallel to $M\,O$.

Measure the distance $M\,W$, and then lay off one-twelfth this distance (or the distance to a scale of 1 in. equal to 1 ft.) from N on the line $N\,O$, making the distance $N\,N'$.

In the same manner and to the same scale lay off the distance $N' Q = M' M'$ upon the line $M' O$.

Join M' and N' by a straight line.

This distance $M' N'$ is the required length of the brace to a scale of 1 in. = 1 ft.

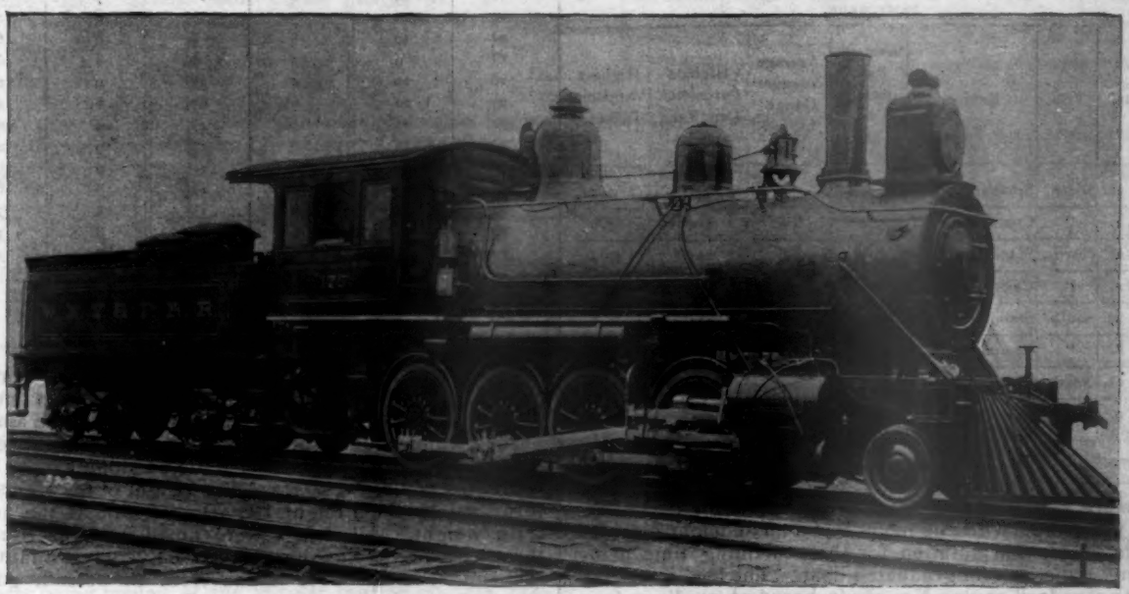
To lay off this length full size, lay off on the edge of the board the distance $M' K = 1$ ft., and draw the line $K L$ at right angles to it until it cuts the diagonal $M' N'$ or $M' N'$ produced.

On one arm of the square take a length of one foot. $M' K$, and on the other arm the length $K L$.

Taking the diagonal connecting these two points as the unit of length, apply it to the timber as many times as there are feet in the length of the panel. Should there be odd inches in the panel length, lay off this distance (as $M' K'$) the same as the one foot $M' K$ was laid off. Draw the line $K' L'$ at right angles to it, and apply the distance $M' L'$ in addition to the distance already obtained by the application of the distance $M' L$, to get the exact length (t, fig. 1) in the brace required.

To obtain the actual dimensions of the angle-blocks, lay off on the diagonal $M' N'$ the actual width of the brace $M' Z'$ and $N' P'$ the same as before, and draw the lines $Z' W'$ and $P' Q'$.

The length of the line $M' W'$ is the length of the vertical side (r, fig. 1) of the angle-block, and $N' Q'$ is the length of its horizontal side (s, fig. 1). These dimensions are full size.



COMPOUND LOCOMOTIVE FOR WESTERN NEW YORK & PENNSYLVANIA RAILROAD.

BUILT BY THE BALDWIN LOCOMOTIVE WORKS, PHILADELPHIA.

TESTS OF A COMPOUND LOCOMOTIVE.

We have received from Mr. A. Vail, General Master Mechanic of the Western New York & Pennsylvania Railroad, reports of a comparative test of two consolidation freight engines—one the standard pattern of the road and the other a compound engine of the Vauclain four-cylinder type—recently made on that road. This report we give herewith.

The results of the tests are given in tables 1, 2, 3, 4 and 5 appended, and in the remarks on the tests made by Mr. Vail, which are given below. A number of indicator cards taken are not given here, owing to lack of space and time.

The accompanying illustration, from a photograph, shows the compound locomotive No. 175.

The engines, as will be seen from the dimensions given below, are of the same size and identical in all respects, except as far as the different arrangement of the cylinders of the compound required. The dimensions are as follows:

	Compound No. 175.	Standard No. 169.
Diameter of cylinders	H.P. 13 in. / L.P. 21 "	19 in.
Stroke " "	26 "	26 "
Throw of eccentrics	5 "	5⅜ "
Maximum travel of valve	5 "	5⅛ "
Lead of valves	H.P. ⅛ " / L.P. 3/16 "	1/16 "
Outside lap of valves	H.P. 7/8 " / L.P. 5/8 "	7/8 "
Size of steam-ports	21⅜ × 1½ in.	16 × 1⅞ in.
Size of exhaust-ports	21⅜ × 7 "	16 × 2⅜ "
Bridge	3 in.	1 in.
Inside diameter of dry-pipe	6½ "	6¼ "
Exhaust nozzles	Double, 3⅜ in.	Double, 3⅜ in.
Weight in working order	129,600 lbs.	126,870 lbs.
Weight on drivers	116,550 "	110,650 "
Weight on truck	13,050 "	16,220 "
Tubes, number and diameter	261—2 in.	261—2 in.
" length	12 ft. 11⅛ in.	12 ft. 11⅛ in.
Size of grate	41⅛ × 101½ in.	41½ × 101½ in.
Grate area	29 sq. ft.	29 sq. ft.
Total heating surface	1,879 " "	1,879 " "
Number of pairs of drivers	4	4
Diameter of drivers	50½ in.	50½ in.
Total wheel-base	21 ft. 9 in.	21 ft. 9 in.
Rigid wheel-base	14 " 0 "	14 " 0 "
Pressure of steam carried	175 lbs.	160 lbs.
Fuel used	Bituminous coal.	

COMMENTS.

Apparatus Used.—Both engines had the cylinders piped for indicators in the usual way, the pipes being carefully lagged with asbestos and felting. A high grade pyrometer was inserted in the smoke-box midway between the flue sheet and the diaphragm, and placed so as to be in full view of the operator on the front end. A vacuum gauge was connected with the smoke-box by a ¾-in. pipe passing from the gauge to the cab, and by a return bend to the smoke-box; the object in this long connection being to do away with the constant jumps and vibrations of the water column.

The vacuum gauge was made of two ½-in. glass tubes 36 in. long, connected at the bottom with a rubber tube and half filled with colored water. A Thompson water meter was connected with the feed pipe, and used to

TABLE 1. FEED-WATER TEST BETWEEN BUFFALO AND MACHIAS.

		Standard.	Compound.
Total pounds feed water used.	Lbs.	44788	36628
Feed water used per hour.	Lbs.	19473	16649
Average I.H.P. per hour.	I.H.P.	684.7	702.5
Pounds feed water per I.H.P. per hour.	Lbs.	28.44	23.7
Pounds steam accounted for by indicator, per I.H.P. per hour, at release.	Lbs.	23.04	18.01
Percentage of feed water accounted for by Indicator.	%	81.	76.
Loss due to leakage, condensation and other causes,	%	19.	24.
Percentage of feed water used per I.H.P. per hour favor Compound.	%		16.6

NOTE.—Cylinder cocks and Piston packing on Compound leaking.

TABLE 3. SUMMARY OF PYROMETER AND VACUUM GAUGE READINGS ALL TRIPS MADE.

Date.	Trip.	Engine.	Average Pyrometer. Deg. Fahr.	Average Vacuum Gauge. Inches.	Highest Pyrometer. Deg. Fahr.	Highest Vacuum. Inches.
Aug. 20.	South.	Standard 169.	655°	5.4	820°	9.5
Sept. 1.	"	Compound 175.	594°	2.6	812°	7.0
Aug. 21.	North.	Standard 169.	709°	6.6	820°	10 5
Sept. 2.	"	Compound 175.	639°	3.6	730°	7.0
Aug. 27.	South.	Standard 169.	700°	6.5	887°	11.0
Sept. 8.	"	Compound 175.	646°	1.7	774°	6.5
Aug. 28.	North.	Standard 169.	695°	7.1	835°	11.0
Sept. 9.	"	Compound 175.	642°	3 8	774°	6.0

NOTE.—Compound trip of September 3 not included.

measure the water fed into the boiler. Only part of the test was made with the meter when an accident disabled it, the water consumption for the remaining time being taken by means of a graduated float. The feed water test of the standard engine No. 169 is based on readings from the meter.

TABLE 2. VACUUM GAUGE BETWEEN BUFFALO AND EAST AURORA.

Speed. Miles per hour.		Vacuum Gauge. Inches.		Reverse Lever. Notch.	
Standard.	Compound.	Standard.	Compound.	Standard.	Compound
10	17	7	2	6	2
24	22	7	5	8	2
23	23	7	3	9	6
20	26	6	3	9	6
21	23	4½	2½	9	6
19	21	4	2	9	6
16	19	5	2½	9	6
22	18	5	2	8	6
25	18	6	2¼	8	6
21	19	7	3	8	2
18	15	8	1	8	6
17	14	8	¾	8	6
16	12	8	1	7	6
10	11	5	½	2	6
22	10	8	½	8	6
18	9	5	½	8	6
16	20	4	3½	9	2
23	22	6½	6½	6	2
20	18	5½	4½	9	2
20	15	6	3¼	9	2
21	13	8	1½	9	6
23	14	8	1¾	8	6
22	20	10	5½	8	3
20	23	9½	4	8	3
20	25	6	4½	8	3

Standard Engine hauling 47 empties.
Compound Engine hauling 50 empties.

both engines were cleaned and the front ends dumped. Then the fires were banked with coal taken from another engine, so that the coal noted as consumed is the amount burned while hauling the train only. No allowance was made for coal and water used while on sidings.

Method of Getting Data.—The weight of the trains was furnished by the Freight Department, and is the actual train weight. All delays were noted, and the time the throttle valve was closed was taken. Every two minutes of the run readings were made from the steam gauge, pyrometer and vacuum gauge. Cards were taken on an average of every two minutes. The speed was determined

TABLE 4. VACUUM GAUGE AND PYROMETER IN CONNECTION WITH SPEED AND CARD DATA BETWEEN BUFFALO AND HOLLAND.

Speed. Miles per hour.		Boiler Press. Lbs.		Throttle.		Reverse Lever. Notch.		I.H.P.		Vacuum Gauge. Inches.		Pyrometer. Deg. Fahr.	
No. 169.	No. 175.	No. 169.	No. 175.	No. 169.	No. 175.	No. 169.	No. 175.	No. 169.	No. 175.	No. 169.	No. 175.	No. 169.	No. 175.
21.5	27.8	153	168	Full	Full	9th.	6th.	558	799	6	3	684°	685°
20.6	26.0	149	171	"	"	"	"	565	739	4½	2½	684°	617°
23.3	21.5	157	165	"	"	"	"	682	700	4	2	639°	572°
22.3	25.1	155	166	"	"	"	"	675	801	5	2½	639°	594°
15.2	16.9	153	170	"	"	"	"	620	617	5	2	639°	549°
16.1	16.1	146	168	"	"	8th.	"	672	542	6	2¼	594°	572°
22.3	13.4	145	169	"	"	"	2d.	748	706	7	3	717°	617°
17.9	14.3	149	173	"	"	"	"	601	790	8	3½	717°	662°
15.9	29.0	151	160	"	"	7th.	6th.	694	840	8	3½	819°	639°
22.3	16 1	154	170	"	"	8th.	4th.	823	832	8½	2½	717°	639°
26.0	15.2	158	168	"	"	"	"	649	657	4	2	594°	639°
24.2	14.3	143	173	"	"	9th.	"	605	719	5½	2	752°	662°
19.7	12.5	150	174	"	"	"	2d.	571	682	6	2½	684°	617°
32.3	11.6	153	172	"	"	"	6th.	735	469	8	2½	662°	594°
23.3	13.4	155	172	"	"	"	2d.	742	707	7	3¼	729°	639°
13.4	16.9	156	169	"	"	6th.	"	836	985	4	3¼	752°	583°
7.2	21.4	136	169	⅛	¾	1st.	6th.	423	691	5	3	717°	628°
15.2	32.6	140	170	Full	⅞	7th.	"	676	741	6½	3	684°	662°
16.1	11.6	155	170	"	Full	"	2d.	783	626	4½	2¼	717°	594°
27.8	15.2	142	172	"	"	10th.	6th.	474	563	4½	2¼	639°	594°

Method of Getting Coal Consumption.—The coal put on the tank was weighed on track scales at Buffalo, and on the return the coal remaining was weighed on the same scales. On the arrival of the engines at Olean the fires of by a Boyer speed recorder, the chart of which was used for the vacuum gauge statements. The number of times the injector was applied was noted, and a deduction made for the water wasted from the overflow.

TABLE 5. COMPARISON OF FUEL AND WATER CONSUMPTION OF STANDARD AND COMPOUND ENGINES 169 AND 175.

First round trip Standard Engine. First round trip Compound Engine.

Engine.	Date.	Number of Cars Handled.	Weight of Train in Pounds	Average Weight of Train.	Time on Road.	Actual Running Time.	Time Throttle was Open.	Pounds Coal Used.	Pounds Water Used.	Pounds Train Haul per lb. Coal.	Pounds Water Evap. per lb. Coal.	Average Steam Pressure.
Standard.	Aug. 20.	38 emp. South.	738960	1697730	10hrs. 35m.	8hrs. 16m.	7hrs. 1m.	12800	86150	132.6	6.73	145.7
	" 21.	40L 1E. North.	2656500									
Compound.	Sept. 1.	47 emp. South.	1001950	1827615	10 " 23 "	8 " 2 "	6 " 32 "	9580	73870	190.8	7.71	161.6
	" 2.	42L 2E. North.	2653980									

Percentage of train hauled per lb. coal favor of Compound 30.5%
" " water evap. " " " " " " 12.7%

Second round trip Standard Engine. Second round trip Compound Engine.

Standard.	Aug. 27.	47 emp. South.	1042450	1832941	11hrs. 16m.	8hrs. 22m.	7hrs. 28m.	16000	95640	114.5	5.98	149.7
	" 28.	44L 2E. North.	2623433									
Compound.	Sept. 3.	50 emp. South.	1093200	1965559	12 " 59 "	8 " 47 "	No record.	10730	78520	183.2	7.32	166.7
	" "	46L 2E. North.	2837918									

Percentage of train hauled per lb. coal favor of Compound 37.5%
" " water evap. " " " " " " 18.3%

Third round trip Standard Engine. Third round trip Compound Engine.

Standard.	Aug. 27.	47 emp. South.	1042450	1832941	11hrs. 16m.	8hrs. 22m.	7hrs. 28m.	16000	95640	114.5	5.98	149.7
	" 28.	44L 2E. North.	2623433									
Compound.	Sept. 8.	47 emp. South.	1082675									
	" 9.	45L. 2E. North.	2870233	1976454	11 " 35 "	7 " 36 "	6 " 52 "	9700	78460	203.7	8.09	169.6

Percentage of train hauled per lb. coal favor Compound 43.8%
" " water evap. " " " " " " 26.0%

Summary of all trips made by both Engines.

Standard.	Two rou'd	trips.	South.	1781410	3530671	21hrs. 51m.	16hrs. 38m.	14hrs. 29m.	28800	181790	122.6	6.31	147.7
			North.	4279933									
Compound.	Three "	"	South.	3177125	5769628	34 " 57 "	24 " 25 "		30010	230850	192.2	7.69	166.0
			North.	8362131									

Percentage of train hauled per lb. coal favor Compound 36.2%
" " water evap. " " " " " " 17.9%

No discrimination was made in regard to coal, the tenders being loaded at the regular coaling pockets, taking it as it came. The engineman and fireman were not instructed in any way as to how the engines were to be run or fired, each man exercising his own judgment both in running and firing. The trains the tests were made with were regular scheduled trains, and the same time was made as with all other regular freight trains.

Compound engine No. 175 and simple engine No. 169 are exact duplicates, except the compound cylinders on engine No. 175; they were also built at the same time, being an order of two out of an order of seven.

The tests with engine No. 169 were made under favorable circumstances, the weather being fine and the rail good. The first test with the compound was made under the same circumstances as with No. 169; the second test with No. 175 was quite different; the run from Buffalo to Olean was made in the daytime, weather fine and rail good. On reaching Olean, No. 175 was ordered to return to Buffalo with a train without having her fire cleaned or front end dumped out, and left Olean for Buffalo about 8.30 in the evening. The weather was bad and rainy, and No. 175 slipped badly, consequently more fuel was consumed than on the former trip.

We were not quite satisfied with this test, therefore thought it advisable to make one more trial trip with No. 175, which was done under favorable conditions, the weather being fine and the rail good. This made three trial trips with the compound and two with the simple engine.

Our report shows the performance of the two locomotives in the tests made, which was done with great care, and every precaution taken to make the tests between the two kinds of locomotives as complete as possible.

A careful study of the tables will show the completeness of the test, and the results will be of interest to all locomotive men.

THE ESSENTIALS OF MECHANICAL DRAWING.

BY M. N. FORNEY.

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(*Continued from page* 423.)

CHAPTER XIII.

TOOTHED GEARING.

FOR transferring motion or power to or from revolving shafts or spindles what is called toothed gearing is used perhaps more than any other kind of mechanism. The principles of its construction have been discussed a great deal, and the student will find that much has been written about it which is hard to understand, and that there is still a good deal of difference of opinion with reference to the theory and construction of such gearing. There is not room in a series of articles like these to consider the subject fully, and therefore only some of its elementary principles will be explained here.

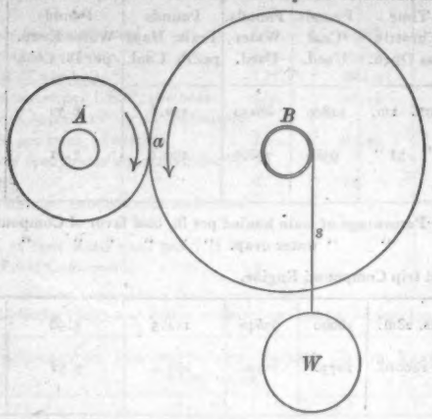
Toothed gearing may be divided into three general classes, *spur*, *bevel* and *screw* gearing. In the former, the axes of the driving and driven wheels are parallel to each other; and their action in relation to each other is similar to that of two revolving cylinders whose surfaces are in contact with each other and whose axes are parallel, as represented by fig. 333. The action of bevel wheels is similar to that of two revolving cones, whose surfaces are in contact, and whose axes may be at any angle to each other, as will be more fully explained hereafter. In screw gearing a toothed wheel is driven by a screw, and their axes are usually at right angles to each other.

SPUR GEARING.

If the peripheries of two wheels, *A* and *B*, fig. 333, one of half the diameter of the other, are in contact at *a*, and either (say the smaller one) is made to revolve, the other will also turn,

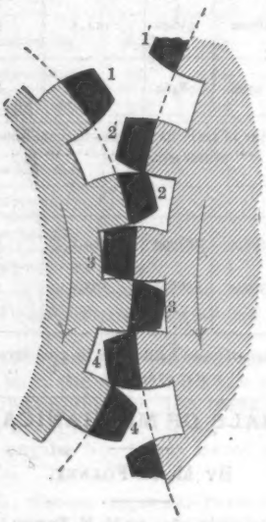
provided its resistance to turning does not exceed that of the friction between the surfaces in contact. If these surfaces do not slide on each other, they will both move through the same distance in the same time. This surface speed is called the *linear*

Fig. 333.



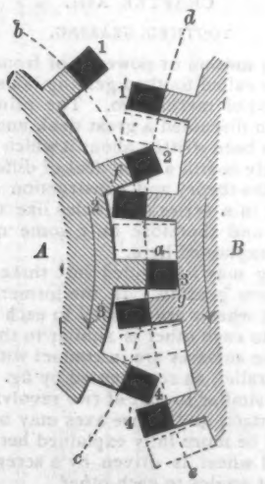
velocity. As the circumference of *A*, the small wheel, which is supposed to be driving *B*, the large one, is only half that of *B*, the latter will be turned only half of a revolution, while *A* is turning all the way around—that is, while *A* is turning 360 degrees of a

Fig. 334.



revolution *B* is turned only 180 degrees. The amount of this turning, expressed in degrees or angular units, is called the *angular velocity*. Thus while *A* is turning a complete revolution, or 360 degrees, *B* is turned only half way round, or 180 degrees. The

Fig. 335.



angular velocity of *B* is therefore only one-half of *A*. It will be seen, then, that while the linear velocity of the circumferences of the two such wheels is the same, the angular velocity of the large one is only half that of the small one. This angular velocity is always in *inverse proportion* to the diameters of the wheels. The relative velocities of wheels of different sizes will be discussed farther on.

It has been remarked that if the wheels are in contact, that if one of them is turned the other will also revolve, provided the resistance to turning is not greater than the friction between the two wheels. Suppose, now, that the wheel *B* was required to lift a weight, *W*, by means of a string, *s*, wound around its axle. By varying the pressure of the wheel *A* upon *B* at the point of contact *a*, the friction between the wheels may be made sufficient for the lifting of the weight, if the latter is not too great. Two smooth wheels in contact will, however, always be liable to slip in relation to each other. As it is often absolutely essential that they should not slip at all, but that their motion in relation to each other should be "*positive*," as it is called—that is, they should always maintain definite relative positions, and also to increase their capacity for transferring power from one to the other—the peripheries of such wheels are provided with teeth which consist of projections, or *addenda* as they are called, and depressions or spaces to receive the addenda. Thus, suppose that in fig. 334 the dotted lines *b a c* and *d a e* represent arcs of the circumferences of the wheels *A* and *B*, fig. 333, but drawn to a larger scale, and that the portions which are shaded in black represent the projections, or *addenda*, and that the spaces between the dotted arcs and the parts which are cross-lined represent the depressions in the wheels, it is obvious that with such wheels neither of them can turn without turning the other, unless some of the projections or teeth are broken off. It will be noticed that the spaces between the teeth are considerably wider than the teeth themselves. The latter are therefore comparatively weak, and could be easily broken. The reason why teeth of the form represented in the figure must be made narrow is in order to be able to clear each other as the wheels revolve. Thus, supposing that the wheel *A* is driving *B* in the direction represented by the darts, it will be seen that the tooth 2 is in contact with 2' at *f*, and that there is then just barely enough room for the tooth 3 to clear 3' at *g*, and for 4 to clear 4'. Consequently, when teeth are made of the shape represented, the spaces must be considerably wider than the teeth themselves. Another difficulty with this form of tooth will be seen if we suppose that *A* is held fast in the position in which it is represented in fig. 334. *B* could then be moved in the direction of the dart until its teeth occupied the positions shown by the dotted lines without affecting *A*. In other words, there might be what is called "lost motion" or "back-lash" between the wheels, and it would not be certain that the one wheel would drive the other at a uniform speed. If, however, the faces of the teeth, instead of being made straight, as shown in fig. 334, were curved, as in fig. 335, it will be seen that they can then be made thicker, and are consequently stronger than they would be if made of the form shown in fig. 334. It will also be plain that there is very little or no lost motion or back-lash between such teeth, and that three of the teeth on each wheel are in contact with three corresponding teeth on the other wheel at the same time, which adds to the steadiness of motion of the two wheels, and increases their durability. It is also very important that the relative velocities of the two wheels should be uniform, and that the transmission of the force from one to the other should be smooth and free from shocks or blows, and that the sliding of the teeth should cause as little loss from friction as possible.*

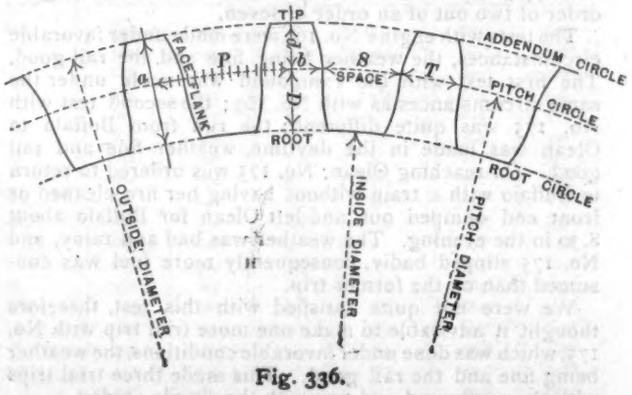


Fig. 336.

For this reason the form of the teeth should be such that the wheels will work together in precisely the same manner as if they were impelled merely by the friction of the surfaces of cylinders, or, in the case of bevel wheels, cones in contact. The attainment of these objects depends chiefly upon the form and proportions of the teeth.

* "Mechanical Drawing," by William H. Thorne.

In designing spur wheels which gear into each other, it is always imagined that there are what may be called two primitive cylinders of a given diameter which are in contact with each other. Thus in fig. 333 the two large circles represent the peripheries of the cylinders, and in figs. 334 and 335 portions of these circles are represented by dotted arcs. These circles are called the *pitch circles*. The *pitch* of the teeth is their distance apart, measured from center to center on the pitch circles, and is equal to the thickness of a tooth plus the space between adjoining teeth. Thus in fig. 336 the distance P from a to b indicates the pitch, which is divided into sixteen equal parts.

From the same fig. it will be seen that the outside end of a tooth is named its *tip*, its base is called the *root*; the surface outside of the pitch circle which comes in contact with the teeth of the adjoining wheel is the *face*, and that part within the pitch circle is the *flank*. The circle which defines the outside limits of the teeth or addenda is called the *addendum circle*, and its diameter is the *outside diameter*. The diameter of the pitch circle is the *pitch diameter*. The circle which defines the limits of the roots of the teeth is the *root-circle*, and its diameter is called the *inside diameter*.

In designing gear wheels, different engineers have adopted different proportions for their teeth. Unfortunately, there has been no agreement among them with reference thereto; and the learner will find that nearly every writer on the subject has adopted proportions different from his predecessors. The following are taken from Richard's "Manual of Machine Construction for Engineers," and are, perhaps, simpler than those of any other system, and probably equally as good as some which have only abstruse mathematical formulæ and Greek notation to recommend them. These proportions will be understood by referring to fig. 336, in which the same letters that are employed in the table are used to designate the same parts:

PROPORTIONS FOR THE TEETH OF GEAR WHEELS.

P = Pitch which is divided into 16 parts.
T = Thickness of tooth measured on pitch circle = 7 parts.
S = Space between teeth measured on pitch circle = 9 parts.
d = Depth from pitch circle to tip of tooth = 5 parts.
D = Depth from pitch circle to base of tooth = 7 parts.
$D + d$ = Whole depth of tooth = 12 parts.
R = Thickness of rim and arms of wheel = 8 parts.
L = Length of tooth measured parallel to axis of wheel = 3 or 4 times the pitch or 4 P.

It will be observed that the depth of the teeth outside of the pitch circle is made less than that inside of this circle. The object of this is to prevent the tips of the teeth from touching the bottoms of the spaces between them. It will also be seen that the thickness of the teeth is less than the width of the spaces. They are made in this way when teeth are cast and used without finishing; on account of the irregularities of the teeth, there will thus be room enough for them in the spaces. The thickness of the teeth which are cut by a machine and the width of the spaces between them may be made the same or nearly so.

Fig. 337.

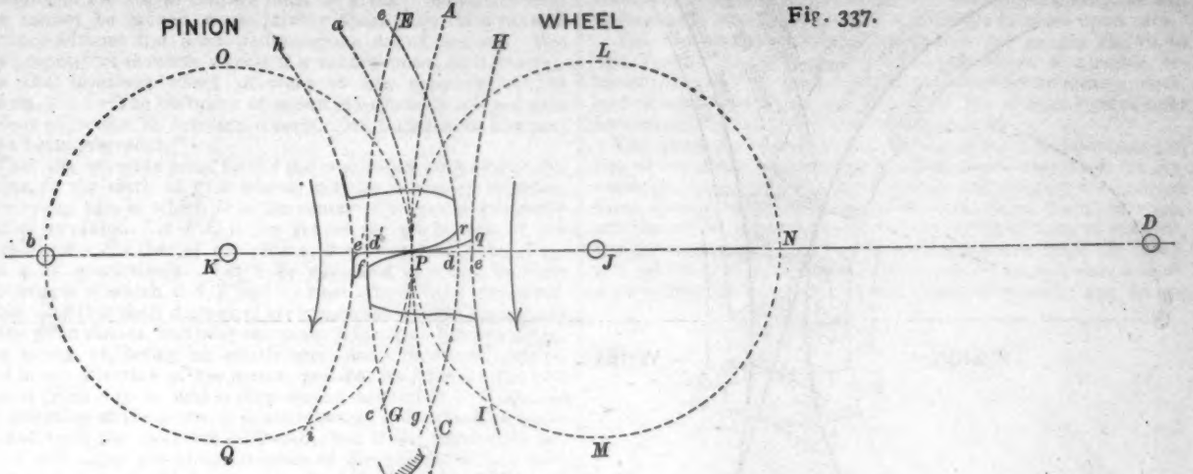
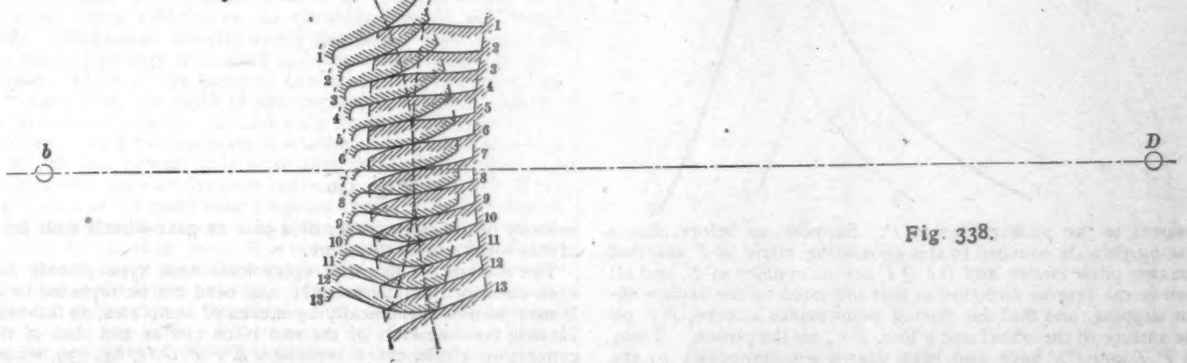


Fig. 338.



The form of the teeth of wheels should fulfill the following conditions: 1. It should be such that the linear velocity of the driven wheel at its pitch circle will be the same as that of the driving-wheel—that is, that there should be no shocks or irregularities in the relative speeds of the two wheels. 2. The friction of the teeth should be reduced to a minimum. 3. They should have the maximum strength, and to this end the strains transmitted from one wheel to the other should be distributed over as large a number of teeth as possible—that is, when they engage with each other, they should remain in contact or "have a bearing" until they are disengaged. It will be shown that these conditions will be fulfilled if their outlines are formed of cycloidal or involute curves, the reasons for which will now be explained.

CYCLOIDAL GEAR TEETH.

Let D and b, fig. 337, be the centers of a wheel and pinion, and $D\,P$ and $b\,P$ be radii. With D and b as centers with these radii, describe arcs $A\,P\,C$ and $a\,P\,c$ of pitch circles, which will be tangent to each other at P, and unite the centers D and b by a straight line, $D\,P\,b$. From P the tangent point of the pitch circles, lay off on each side distances $P\,d$ and $P\,d' = \frac{5}{16}$ of the pitch, and $P\,e$ and $P\,e' = \frac{7}{16}$ of the pitch. Then draw arcs of circles $E\,d'\,G$, $e\,d\,g\,H\,e\,I$, and $h\,e'\,i$ through the points thus laid down. These arcs will define the limits of the tips and roots of the teeth.

From a center, J, on the line $D\,P\,b$, and with a radius equal to one-half $b\,P$ that of the pinion A, describe what is called a *generating circle*, $L\,P\,M\,N$. Let it now be imagined that the center D of the wheel, b of the pinion and J of the generating circle are all fixed, and that the wheel, pinion and generating circle all turn in the direction indicated by the darts without slipping on each other at their common tangent point P. Let it further be supposed that a tracing point is attached to the generating circle at P, and that as the wheel, pinion and circle revolve, that this point describes an internal or hypocycloidal curve $p\,q$ on the surface of the wheel and an epicloidal curve, $p\,r$, on the surface of the pinion.* Then as these curves are

* The method of drawing these curves was described in Chapter XI. see Problems 92 and 93.

traced simultaneously by the same point on both the wheel and pinion, the two curves will touch or be tangent to each other at every position in the path of the point.

Next, take a center, K, on the line $b\ P\ D$, and with a radius equal to $\frac{1}{2}\ b\ P$ describe another generating circle, $O\ b\ Q\ P$,

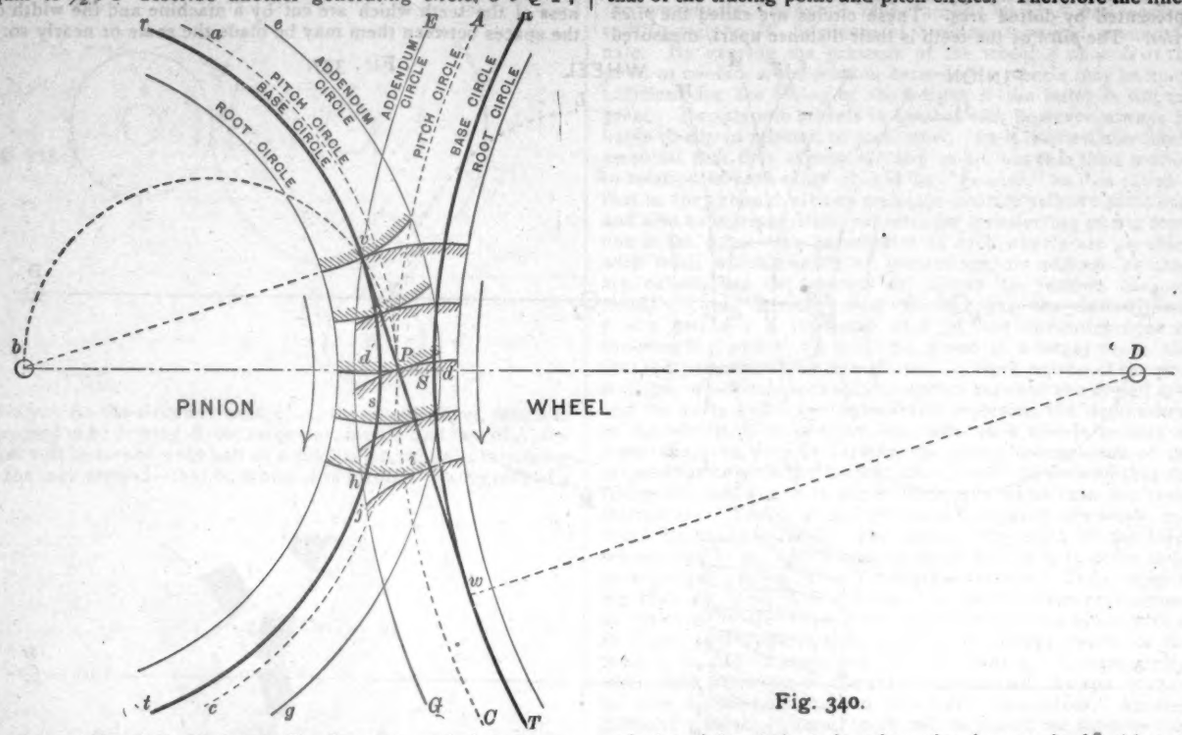


Fig. 340.

tangent to the pitch circles at P. Suppose, as before, that a tracing point is attached to this generating circle at P and that the two pitch circles and $O\ b\ Q\ P$ are in contact at P, and all turn in the reverse direction to that indicated by the darts without slipping, and that the tracing point marks a curve, $P\ f$, on the surface of the wheel and a line, $P\ e'$, on the pinion. Then, as $P\ f$ and $P\ e'$ have also been drawn simultaneously by the same point, they must touch or be tangent to each other at every

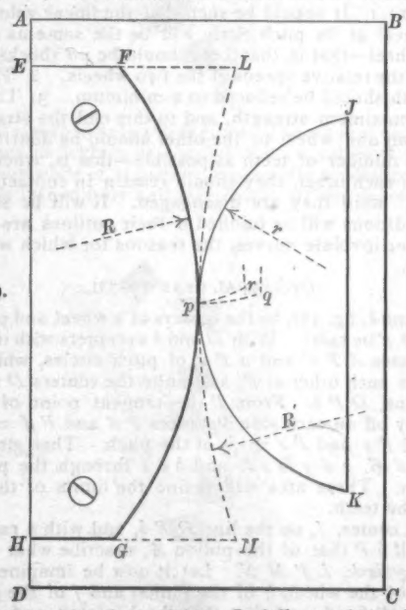


Fig. 339.

position in the path of the point. It follows, then, that if the curve $f\ P\ q$ forms the outline of a tooth on the wheel, and $r\ P\ e'$ that of a tooth of the pinion, that they will be tangent to each other in every position in which these outlines are in contact while the wheel and pinion revolve. This is shown in fig. 338, in which 1, 2, 3–14 and 1′, 2′, 3′–14′ represent successive positions of the curves $f\ P\ q$ and $r\ P\ e'$ of fig. 337. It will be seen that they are tangent to each other in every one of these positions.

Furthermore, if the pitch circles and generating circles roll in contact with each other without sliding while the curves are drawn, their form must be produced by the angular movement of the tracing point, which is equal to that of the two pitch circles. Consequently, the motion which is transmitted from the pinion to the wheel, or *vice versâ*, will have the same velocity as that of the tracing point and pitch circles. Therefore the linear velocity of the pitch circles of a pair of gear-wheels with teeth of this form will be the same.

The method of drawing epicycloids and hypocycloids has been described in Chapter XII, and need not be repeated here. It may be done graphically by means of templates, as follows: Having the diameters of the two pitch circles and that of the generating circle, cut a template, $E\ F\ P\ G\ H$, fig. 339, whose radius R is equal to that of the pinion, fig. 337. Fasten this on a smooth board, $A\ B\ C\ D$. Then make another template, $J\ p\ K$, with a radius, r, equal to that of the generating circle. Place these in contact at p. Then roll the loose template $J\ p\ K$ on the line $p\ F$, and place a tracing point in contact with $J\ p\ K$ at p, so that it will trace a curve, $p\ r$, on the board below it. This will be the form of the face of the tooth of the pinion. Find the radius and center of an arc which approximates closely to this curve, and mark the position of the center in relation to the pitch circle $F\ p\ G$, and transfer it to the drawing. Then draw a circle through it from the center of the pinion, and the centers of the curves for all the other teeth will be on this circle. Next make another template, $E\ L\ M\ H$, whose outline $L\ p\ M$ is concave and is drawn with a radius, R', equal to that of the wheel. Then with the template $J\ p\ K$ representing the generating circle, draw the curve $p\ q$, which will be the shape of the flank of a tooth of the wheel, which may be transferred to the drawing by the method described. In a similar way the curves for the faces of the teeth of the wheel and the flanks of those of the pinion may also be drawn by making concave and convex templates, which will conform to the lines $F\ p\ G$ and $L\ p\ M$ respectively.

In drawing cycloidal-shaped teeth, any sized generating circle may be used. It will be found, however, in drawing hypocycloids, that if the diameter of the generating circle is equal to the radius of the fundamental or pitch circle, as is the case with $O\ P\ Q\ b$ in fig. 337, that the curve $P\ e'$ becomes a straight line, and coincides with a radius of the fundamental circle. It has been found by experience, especially in small gear wheels, that if the width of the root of a tooth is less than that formed by two radii tangent to the curve of its face, that the tooth is unduly weakened. Therefore the diameter of the generating circle should not be less than the radius of the pinion. The teeth of wheels having the same pitch, which are intended to interchange with each other, should all be drawn with generating circles of the same diameter.

INVOLUTE TEETH.

The outlines of the teeth of gear wheels may also be made of involute form. Such teeth Mr. Unwin, in his "Elements of Machine Design," (new edition) says, "have two remarkable

properties. All involute wheels whose teeth have the same pitch and the same obliquity of the line of contact work well together. A pair of involute wheels may be drawn a little farther apart without the accuracy of action of the teeth being impaired, though the arc of contact is diminished. Involute wheels cannot be made with very long teeth, because then the obliquity of the line of contact must be great. Hence the centers cannot be moved much farther apart than their normal distance without too much reducing the arc of contact. But this property of involute wheels is a valuable one, as it neutralizes the injurious effect of wear of the supports of the wheels. . . . The obliquity of action is ordinarily alleged as a serious objection to involute wheels. Its importance has perhaps been overrated."

That the involute form fulfills the conditions required in the action of the teeth of gear wheels may be explained by reference to fig. 340, in which D is the center of a gear wheel and b that of its pinion. $A\ P\ C$ is an arc of the pitch circle of the wheel, and $a\ P\ c$ that of the pinion, the diameters being 8 in. and 4 in. respectively. Let it be supposed now that we have two wheels of which $R\ S\ T$ and $r\ s\ t$ are arcs of their circumferences, and that their diameters are somewhat smaller than those of the pitch circles, but bear the same proportion to each other. If a string, or, better, an elastic steel band, is wound around $r\ s\ t$ in the direction of the arrow, and passes between the two wheels from v to w, and is then wound around $R\ S\ T$, also in the direction of the arrow, it is obvious that if the wheel is made to revolve in the direction indicated, that if the band does not slip it will cause the circumference of the pinion to turn with the same linear velocity as the circumference of the wheel moves. The angular velocity would also be the same as though the pitch circles were in contact and the wheels turned without slipping. From P, the point of contact of the pitch lines, lay off $P\ d$ and $P\ d'$, the depth of the teeth outside of the pitch circles, and draw arcs $E\ d'\ G$ and $e\ d\ g$ through the points thus laid down. If a tracing point is attached to the band at v, and the wheels are turned, it is plain that in moving from v to i the point will trace an involute curve, $h\ i$, on the surface of the pinion, and at the same time a similar curve, $j\ i$, will be traced on the surface of the wheel. As these curves are traced simultaneously by the same point, it is obvious that they must touch each other in every position of the path of the point between v and i, and as the linear velocity of the band is the same as that of the circumferences of the wheels, if the teeth are made of the form of these curves they will impart a uniform linear velocity from the periphery of one wheel to that of the other, and all the teeth between v and i' will be in contact at the same time. Therefore, if the outlines of the teeth of gear wheels are made of the form of these curves, they will fulfill the requirements which are demanded of them.

The flanks of the teeth, especially those of the pinion, or that portion of the flanks within the base circle, may be made of radial form, or, in other words, formed of part of a radial line drawn through the center b, and tangent to the involute curve $h\ i$. In the case of involute, as with cycloidal teeth, the exact curve may be laid down for one tooth, and a radius and center of an arc of a circle may be found which will approximate most closely to the curve, and all the teeth may then be drawn with such arcs. Practically the error arising from the use of these arcs is less than would occur in attempting to make cutters to cut the teeth of absolutely correct shape, except by means of a machine which would automatically generate the curves and form the cutters to them.* In fig. 340 a number of involute curves have been drawn to show that they are tangent to each other in different positions.

(TO BE CONTINUED.)

* Thorne's "Mechanical Drawing."

Gauges for the Standard Coupler.

AN important circular has been issued by Secretary J. W. Cloud, of the Master Car-Builders' Association, in relation to gauges and limits for the M. C. B. standard coupler. The substance of this circular is given below:

In fulfilling the duties assigned to the Executive Committee by the Association in regard to gauges and limits for the standard contour and measurements of the Master Car-Builders' automatic coupler, when new, the Committee has carefully reconsidered the whole question since the discussion on its report to the Convention in June, and in view of this discussion and the action of the Convention upon its report, the Committee believes that it is the desire of the Association to have it act under the instructions of the Convention of 1890, and to make arrangements whereby all parties interested may be able to procure sets of gauges so that all sets will be alike, which can be used to determine whether any and all new couplers of this type are near enough to the standard contour established by the Association to insure proper coupling with one another, in so far as it can be insured by close adherence to the standard contour, and also to establish limits of variation for such of the standard rectilinear measurements of the coupler, only, as will promote the interchangeability of couplers in place upon cars.

The Committee therefore announces the gauges shown in figs. 1 and 2 for the contour line, and thickness of knuckle, respectively, with the limits of variation allowed by these gauges, and it also announces the limits for the standard rectilinear measurements, as given in the table with fig. 3.

The gauge for new couplers shown in fig. 1 is announced in lieu of the gauge proposed in the Committee's report to the Association, because it provides means for gauging the contour lines, excepting the thickness of the knuckle, at points throughout the whole essential extent of the standard form of contour, and it controls the variation in both directions from the standard, whereas the gauge proposed in the report was only a minimum gauge for a portion of the standard contour, and its use

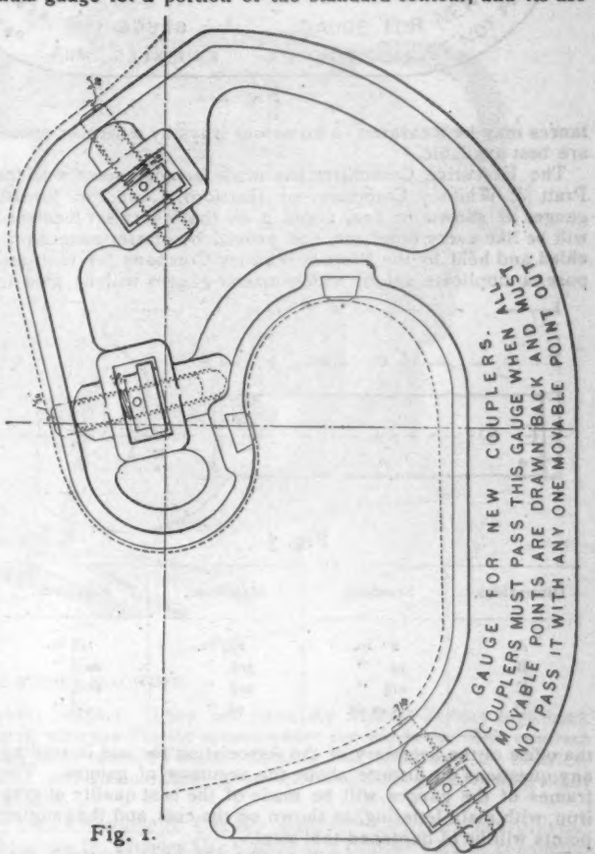

GAUGE FOR NEW COUPLERS. ALL MOVABLE POINTS MUST PASS THIS GAUGE WHEN COUPLERS ARE DRAWN BACK AND OUT. NOT PASS IT WITH ANY ONE MOVABLE POINT OUT.

Fig. 1.

DOTTED LINE IS STANDARD CONTOUR.

would involve numerous measurements at different heights for the maximum variation, instead of gauging for both limits. The figures shown for the variation allowed with this gauge on fig. 1 are the same as those recommended in the report at the same points, and the additional point on the back of the knuckle is allowed to vary the same as was recommended at the guard arm.

The gauge for new knuckles, shown in fig. 2, is announced as a proper gauge for knuckles, allowing $\frac{1}{16}$ in. variation each way from the standard dimension of 3 in. instead of $\frac{1}{16}$ in. one way only, as recommended in the report, because it is thought desirable to allow more than $\frac{1}{16}$ in. variation, on account partly of the necessary taper in cast knuckles.

The limits shown in table given below, which belongs with fig. 3, are announced as proper limits of variation for the standard rectilinear measurements, which are the same as the limits recommended in the report, except that the standard distance A of 2 in. is included herein with an allowable variation of $\frac{1}{16}$ in. each way, and the cross-section D is allowed to vary $\frac{1}{16}$ in. each way from the standard measurement of 5 in., instead of only $\frac{1}{16}$ in. one way, as recommended in the report. The Executive Committee considers it inexpedient to announce limits of variation for dimensions which are not standard, but which were

mentioned in the report, because the Convention ordered that a committee be appointed to report next June on any new standard measurements and limits which may be desirable in connection with the coupler. It is also considered undesirable to provide any specific measuring instrument for the limits of rectilinear measurement given in table with fig. 3, as these dis-

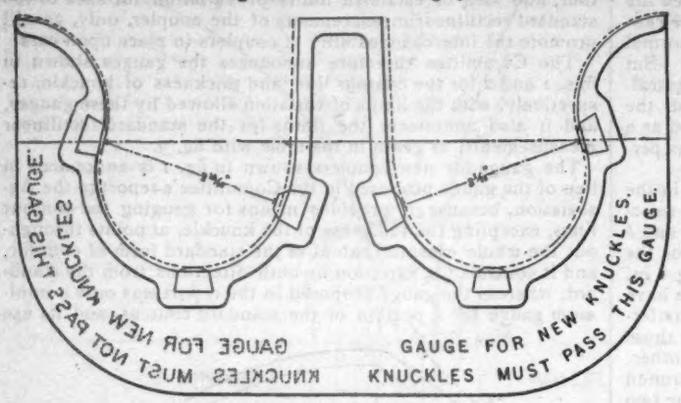


Fig. 2.

tances may be measured in numerous ways by whatever means are best available.

The Executive Committee has made arrangements with the Pratt & Whitney Company, of Hartford, Conn., to furnish gauges as shown in figs. 1 and 2, so that every set furnished will be like every other set, and proved by master-gauges provided and held by the Pratt & Whitney Company for that purpose, a duplicate set of which master-gauges will be filed in

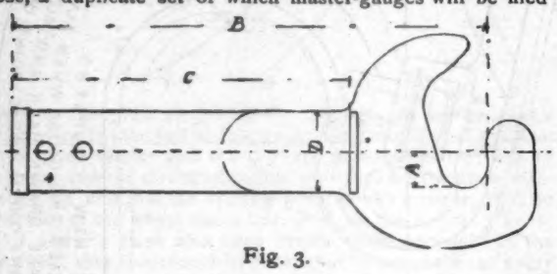


Fig. 3.

Dimensions.	Standard.	Maximum.	Minimum.
A	2 in.	$2\frac{1}{16}$ in.	$1\frac{15}{16}$ in.
B	30 "	$30\frac{1}{8}$ "	$29\frac{7}{8}$ "
C	$21\frac{1}{4}$ "	$21\frac{3}{8}$ "	$21\frac{3}{16}$ "
D	5 in sq.	$5\frac{1}{16}$ "	$4\frac{15}{16}$ "

the office of the Secretary of the Association for use in settling any questions in dispute about the accuracy of gauges. The frames of the gauges will be made of the best quality of gray iron, with plain lettering, as shown on the cuts, and the gauging points will be of hardened tool steel.

The price of the gauges will be $35 per set at Hartford, providing that as many as 50 sets are ordered in advance, but if the number of sets ordered will enable them to make 100 sets in the first lot the price will be 10 per cent. less, or $31.50 per set.

Parties who wish to procure sets of these gauges should therefore place orders with the Pratt & Whitney Company at an early date, and if they prefer to do so, they can make the order conditional on the price not exceeding $35 per set, in which case the necessary fixtures, tools, etc., for making these gauges properly will not be prepared by the Pratt & Whitney Company until they have orders for 50 sets in hand.

Manufactures.

Baltimore Notes.

THE Baltimore & Ohio Company has recently received three passenger locomotives from the Baldwin Locomotive Works; they have 20 × 24-in. cylinders and 78-in. driving wheels. The company has recently ordered 100 Eastman heater cars from the South Baltimore Car Works and 50 Wickes refrigerator cars from the Wells & French Company, of Chicago.

A SERIES of tests of freight trains with a dynamometer car is to be made on the Baltimore & Ohio, under charge of Mr. L. S. Randolph, Engineer of Tests.

THE new shops and freight yard of the Baltimore & Ohio at Brunswick, on the main line, are to be lighted with electric lights.

THE new rail mill of the Pennsylvania Steel Company at Sparrow's Point, Baltimore, was started up for the first time recently, and is now running steadily.

THE Philadelphia Division of the Baltimore & Ohio is to be entirely relaid with 85-lb. rails. Those now in the track are 67-lb. rails. The Metropolitan Branch of the same road is to be provided with block signals throughout.

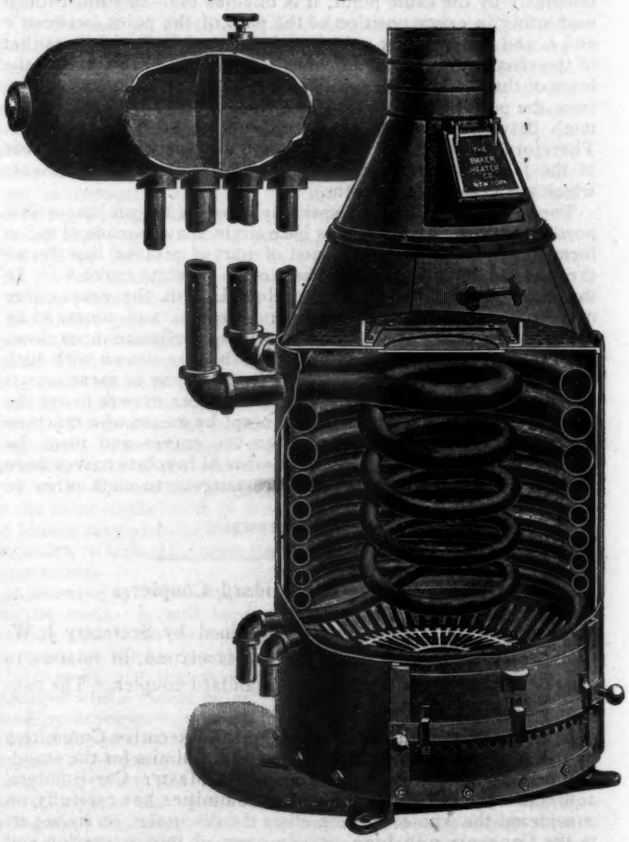
CONTRACTS for building the new North Avenue Electric Railroad have been made with Messrs. E. B. Smith & Company, the builders of the Baltimore Traction Cable Line. The rails are now being delivered, and work will be begun at once on the construction of the road, and it will be pushed to an early completion. The line will extend from North Avenue at York Road to McCullough Street, Guilford Avenue, North Lexington, Charles and Fayette Streets.

The Two-Coil Baker Heater.

THE accompanying illustration shows the latest improvement made in the Baker heater by the use of two generator coils instead of one. The additional coil takes the place of the cast-iron lining of the fire-chamber, and thus utilizes some of the heat heretofore lost. At the same time the circulation is improved.

The water is fed to the heater in the usual manner, both circuits being supplied at the same time. Small holes in bottom and top of the partition or stay, cast crosswise in center of drum, allow the equalization of both the water and the pressure. The fire grate is the same as in the Baker perfected heater, but the grate surface is extended by openings in the rim of the ash-pit, as shown.

With these two coils it is claimed that the coal will kindle as readily, burn as freely, last as long, and leave as few clinkers



THE TWO-COIL BAKER HEATER.

as with any other heater. These are important points, and their absence has caused the failure of previous attempts to use two coils in one fire.

It is also claimed that this new circulation system has even more than double the heating power of the single circuit, for the

reason that each of the two short circuits returns to the fire (their source of heat) twice as often as the one long circuit, and one of the circuits has no cross-over pocket to contend with.

The outside, the larger of the two coils, is 46 ft. 3 in. in length, gradually increasing from 1¼ in. (the usual sized pipe of Baker heater coils) at the bottom, to 2 in. at the top end, at which point it turns upward to the circulating drum. The inner coil is 16 ft. long, and of the same proportions. The two coils are equivalent to 75 ft. of 1¼-in. pipe.

The outer steel casing and other fittings are the same as are used in the latest improved forms of this heater.

Plate Scarfing or Planing Machine.

THE accompanying illustration shows a duplex planing machine built for the special purpose of scarfing plates used in the construction of iron and steel ships. The machine in question was built originally for the Newport News Shipbuilding Company, which needed a machine for scarfing the ends of plates used about the stern-posts and bows of ships, the idea being to accomplish this work by combining two of the machines and connecting them by a platen so arranged as to be adjustable to any desired taper.

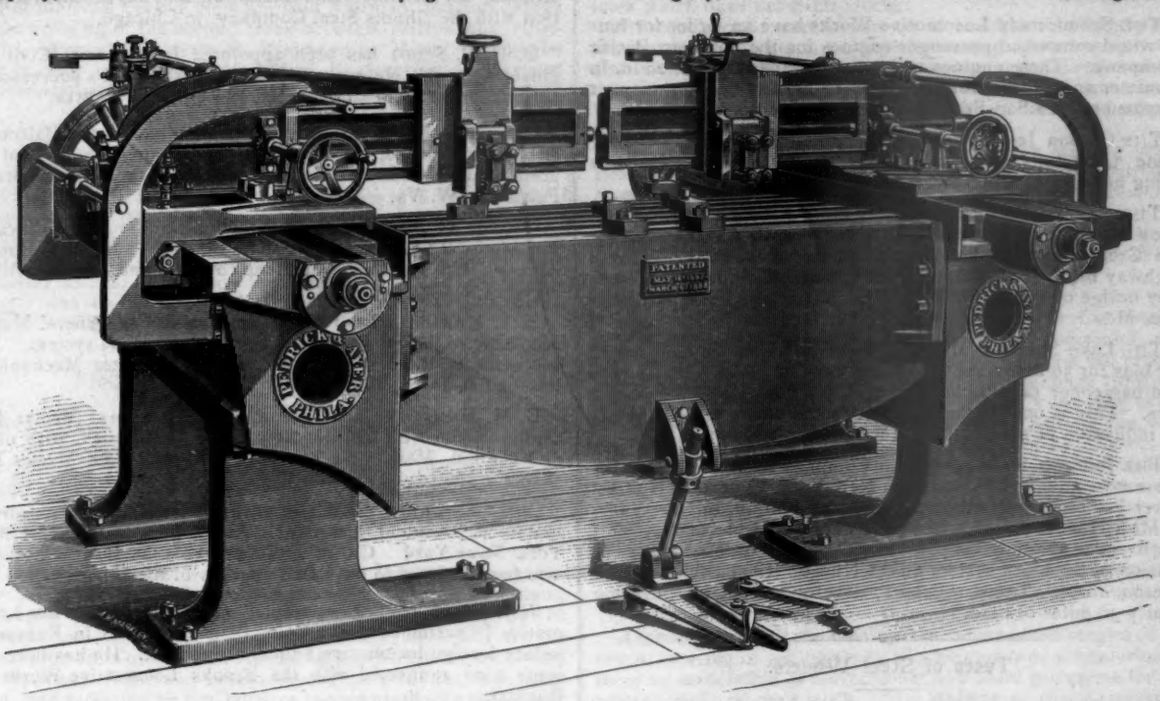


PLATE SCARFING OR PLANING MACHINE.

The machine is really a modification of the Richards patent side-planing machine arranged with right and left-hand tool supports or arms moving over the work, which may be fastened in the usual way to the slotted center-plate or table, connecting the right or left-hand beds. Each traveling head is driven independently by a separate countershaft, and wide plates or frames may be planed or spotted off, using one or both heads on hand or short stroke at will. The work, whatever its size, shape, or weight, remains at rest.

In the machine shown in the illustration the table is made to swivel or to set at certain angles by means of the screw or hand-wheel in front, and is so adjusted for the purpose of scarfing ship plates, but it may be adapted for other work of this class, changes in detail being made as desired. In the machine shown the stroke is 25 × 60 in., and has quick return. Furnished complete, with two countershafts, it weighs 15,800 lbs. The feet are planed on the bottom and bolted to two heavy cast-iron I-beams set on foundations. The operator stands in front between the posts where both plate shafters and all the hand wheels are easily reached.

This machine has proved exceedingly efficient in use. It is built by the well-known firm of Pedrick & Ayer, in Philadelphia.

General Notes.

THE firm of James Reese & Son in Pittsburgh is building a steel steamboat for the Magdalena River in South America. The boat is 120 ft. long, 24 ft. beam, 3 ft. depth of hold, and will draw only 10 in. of water.

THE Servé ribbed boiler tubes, to which reference has heretofore been made, are to be tried in locomotive service, the Southern Pacific, the Mexican Central, and the Grand Trunk having ordered experimental sets of these tubes.

THE Baker Heater Company, of New York, has just shipped six of the latest improved Baker car heaters, fitted in cars built by the Gilbert Car Manufacturing Company, for the Southeastern Railway of England. There is no doubt that the Baker heater will be found a great improvement over the heating systems now in use in that country.

THE Chicago, Burlington & Quincy Railroad Company has just let a contract for 30 new passenger cars, which are to have all the latest improvements. They will be 53 ft. long over all, and will have four-wheel trucks; the wheels will be of cast iron made in contracting chills. The inside finish is to be in mahogany, and the cars will be first class and elegant in every respect. They will have the Scarritt-Forney high-back seat, with the Forney alcove under the windows. The contract has been taken by the St. Charles Car Company, St. Charles, Mo., and the cars are to be delivered during the coming eight months.

THE Centralia & Chester Railroad Company has ordered from the St. Charles Car Campany a complete train, consisting of one baggage, mail and express, one smoking, and one first-class passenger car. The latter will be a very handsome car, having inside mahogany finish, ladies' toilet and wash room, gentlemen's toilet room, and other complete fittings, including Baker improved heater. It will have the Scarritt-Forney high-back seats. This company is building a short road, but is making it a very solid and substantial line, as is shown by the character of the train mentioned. The road-bed will be good, and the locomotives are now under construction at the Baldwin Works.

THE Bucyrus Steam Shovel & Dredge Company recently furnished a quantity of dredging machinery for the works in the harbor of Montreal. These included a set of hoisting engines, which are intended to exert a direct pull of 120,000 lbs. upon a steel wire rope 2½ in. in diameter. There are two cylinders 16 × 18 in. with link motion and Allen-Richardson balanced valves. The main drum is loose upon the shaft, and is driven by a friction clutch at each end. The main shaft is of steel 12½ in. in diameter. The engine is one of the largest hoisting engines ever built.

THE new plant in the power station of the Federal Street & Pleasant Valley Electric Street Railroad Company, Allegheny, Pa., is intended to gradually replace the old complex system of centralized power with all its attendant evils of countershaft-

ing, clutches and belting. The engine is an 18 and 30 × 16 Westinghouse compound, whose governor was recently the subject of interesting experiment on rapidity of adjustment with instantaneous changes of load. As originally intended, the combination consisted of a single 225 Watt-Edison dynamo belted direct from the engine; but the imposition of a second dynamo on the engine, with increased steam pressure on account of the continued trouble with the other system, indicates the success of the change.

THE Risdon Iron Works, San Francisco, Cal., has recently completed two 500-H.P. triple expansion engines for the San Francisco & San Mateo Electric Railroad. The two engines are exactly alike. Each has cylinders 15, 24 and 38 in. in diameter, with 48-in. stroke. The high-pressure and intermediate cylinders have Corliss valve gear, and the low-pressure a slide valve and Myers cut-off. There is a jet condenser 30 × 50 in., and an independent air pump, which is driven by a compound engine with cylinders 5 in. and 10 in. in diameter, and 16-in. stroke.

THE Schenectady Locomotive Works have an order for four 10-wheel compound passenger engines for the Southern Pacific Company. These engines will have cylinders 20 and 29 in. in diameter and 24 in. stroke, and will be used in heavy passenger service between San Francisco and Sacramento.

THE Carbon Iron Company in Pittsburgh has an order for some 3,000 tons of deck and hull plates for new ships now being built at the Cramp yards in Philadelphia, Pa.

THE contracts lately received by the Pittsburgh Bridge Company include one for a bridge 400 ft. long, in seven spans, for the Great Northern Railroad Company at St. Paul, Minn.; a highway bridge of 250 ft. span at Evansville, Ind., and a highway bridge of 138 ft. span over the Antietam Creek, at Antietam, Md.

THE Lake Shore & Michigan Southern Company has asked for bids for 50 first-class passenger cars, 10 combined baggage and passenger cars, 1,000 box cars, 500 coal cars and 300 flat cars. This is one of the heaviest orders of the season, and is an indication of plenty of work for the car-builders.

THE Johnson Railroad Signal Company has the contract for the new signal system on the New York Central & Hudson River Railroad from the Grand Central Station, in New York, to Mott Haven. This will require some intricate and difficult work. The Central Company has also given orders for the extension of the block system on the Hudson River Division from Croton north. There will be 17 new towers put up, covering nearly 30 miles of road.

Tests of Steel Wheels.

SOME tests of the wheels made by the American Steel Wheel Company have shown remarkable results. In some made at the works in South Boston a 33-in. wheel was placed on two solid iron bocks, rim resting on each block. A weight of 525 lbs., falling 17 ft., struck the hub 25 times without any effect except battering the metal. It was then dropped 10 times on the rim, without a fracture. Then a weight of 1,400 lbs. was tried, falling 17 ft., it struck the wheel 11 times but failed to break it.

At another exhibit, in order to test the expansion and contraction of the metal, a wheel was buried in sand and a charcoal fire built around the tread until it was brought to a red heat; then it was taken out and exposed to the atmosphere, which had no effect on it whatever.

The metal used in this wheel is sound, tough and homogeneous throughout, and makes a very superior Miller draw-hook and M. C. B.'s coupler.

PERSONALS.

SYLVESTER T. SMITH has resigned his position as General Manager of the Denver & Rio Grande Railroad.

D. L. FUSNER has been appointed Master Mechanic of the Baltimore & Lehigh Railroad, *vice* W. J. KANE, resigned.

GEORGE M. ADAMS has been appointed Railroad Commissioner of Kentucky in place of J. T. HAGER, who has resigned.

ALBERT GRIGGS has resigned his position as Superintendent of Motive Power of the New York & New England Railroad.

CHIEF ENGINEER C. H. BAKER, U. S. N., has been transferred from the New York Navy Yard to duty at the Norfolk Yard.

JAMES RITCHIE has been appointed Principal Assistant Engineer of the Cleveland, Cincinnati, Chicago & St. Louis Railroad.

THEODORE COOPER, ALPHONSE FTELEY and F. P. STEARNS have been appointed Consulting Engineers of the Boston Rapid Transit Commission.

J. M. GRAHAM has been appointed Superintendent of the Ohio and Midland divisions of the Baltimore & Ohio Railroad, in place of R. BAXTER, resigned.

F. C. LEWIS, formerly with the Youngstown Bridge Company, has been appointed Chief Engineer of the Columbus Bridge Company at Columbus, O.

R. D. WADE, Superintendent of Motive Power of the Richmond & Danville Railroad and its controlled lines, has removed his office from Washington to Atlanta, Ga.

W. M. HUGHES has resigned his position as Engineer of Constructior for the Columbian Exhibition, and has accepted a position with the Illinois Steel Company, in Chicago.

O. H. P. STOOP has been appointed Instructor of Civil Engineering at the Nebraska State University. His successor as City Engineer of Beatrice, Neb., is FRANK S. DAVIES.

C. F. KERCHNER, formerly Superintendent of the Baltimore & Lehigh Railroad, has been appointed Superintendent of the Monongahela Coal and Coke Company, with headquarters at Fairmont, W. Va.

GEORGE C. SMITH, formerly Chief Engineer of the Chicago, Burlington & Quincy, who for some time past has been in South America, has returned from that country, and has established an office in Chicago.

E. S. MARSHALL has resigned his position as General Master Mechanic of the St. Louis Southwestern Railroad system. His successor is R. M. GALBRAITH, formerly Master Mechanic of the road at Tyler, Tex.

E. M. HUMSTONE has been appointed General Master Mechanic of the New York & New England Railroad, with office at Norwood, Mass. He has been for some time Master Mechanic of the road at Hartford.

CHIEF ENGINEER W. W. DUNGAN, U. S. N., has been ordered to duty as President of the Naval Experiment Board at the New York Navy Yard CHIEF ENGINEER J. L. D. BORTHWICK has also been ordered to duty as a member of the Board.

R. J. GROSS has been appointed agent to represent the Locomotive Department of the Columbian Exhibition in Europe to induce foreign locomotive builders to exhibit. He has been for some time connected with the Brooks Locomotive Works at Dunkirk.

ROBERT QUAYLE is now Master Mechanic of the Milwaukee, Lake Shore & Western Railroad, succeeding Mr. John Hickey, whose appointment to the Northern Pacific has been already announced. Mr. Quayle was formerly on the Chicago & Northwestern Road.

CHIEF ENGINEER LEWIS W. ROBINSON, U. S. N., will have charge of the Machinery Department at the Columbian Exhibition. Mr. Robinson is now a member of the Naval Examining Board in Philadelphia, and had charge of the machinery during the Centennial in that city.

LIEUTENANT H. H. BARROLL, U. S. N., has been detached from duty at the Branch Hydrographic Office at Norfolk, Va., and ordered to the *Petrel*. Lieutenant Barroll is well known to readers of the JOURNAL as a frequent and very acceptable contributor to its columns.

J. S. B. THOMPSON has been appointed Assistant General Manager of the Richmond & Danville Railroad, with headquarters in Atlanta, Ga., and will have charge of the distribution of Equipment. T. O. TROY succeeds Mr. Thompson as Superintendent of the Virginia Midland Division.

W. W. THOMPSON has been appointed Master Mechanic of the New York Central & Hudson River Railroad, with headquarters in New York, where he has charge of all running locomotives. Mr. Thompson has been for several years past Road Foreman of Engines on the Manhattan Elevated Railroad.

THE candidates for State Engineer of New York, as nominated by the party conventions, are MARTIN SCHENCK (Democrat), of Greenbush, an engineer of considerable experience and for some time past connected with the State Engineer's office, and VERPLANCK COLVIN (Republican), of Albany, who

was connected with the State surveys of the Adirondack forest region.

JUDGE THOMAS M. COOLEY has tendered his resignation as Chairman and as a member of the Interstate Commerce Commission on account of failing health. Previous to his appointment on the Commission Judge Cooley had a high reputation from his intimate acquaintance with railroad and corporation law, and his services upon the bench, and he has fully maintained that reputation in the difficult position at the head of the Interstate Commission. His retirement will be a loss to the public service.

PROFESSOR N. S. CHAPLIN has been chosen Chancellor of the Washington University in St. Louis. He is a graduate of West Point, and in 1877 was appointed Professor of Civil Engineering in the Imperial University of Japan, which position he retained for five years, at the same time doing considerable service as Consulting Engineer to the Ministry of Public Works in that country. In 1882 he was appointed Engineer of Construction of the New York & New England Railroad, and had charge of the building of the second track between Boston and Hartford. After a short term as Professor in Maine College, he was in 1885 appointed Professor of Engineering in Harvard University, which position he has since held.

OBITUARY.

WILLIAM C. STROUD died at his residence at Rosemont, Pa., September 21. He was a member of the firm of Burnham, Williams & Company, owners of the Baldwin Locomotive Works, and for a number of years had had charge of their financial affairs, acting as Treasurer of the concern. Mr. Stroud was highly esteemed by his associates, and his death will be regretted by many friends.

PROCEEDINGS OF SOCIETIES.

New England Roadmasters' Association.—The Ninth Annual Convention began in Boston, August 19. The following officers were elected for the ensuing year: President, F. C. Clarke; Vice-President, C. P. Lindell; Secretary and Treasurer, G. L. R. French; Chaplain, E. W. Horner; Executive Committee, W. E. Clarke, A. C. Stickney, E. K. Post and F. Holbrook.

Interesting reports were presented by several committees. The report on Track Joints was probably the most important, and upon the whole recommended the angle-bar as the one in general use, the cheapest and most easily handled. At the same time the Committee admitted its imperfections, especially under heavy traffic, and recommended good ballast, care in fitting, and attention to the bolts as indispensable for the proper maintenance of a joint. This report was discussed at considerable length, the general feeling being in favor of a suspended joint, while the suggestion as to maintenance was generally approved. Some members complained of the inferior quality of bolts furnished and others of the lack of sufficient labor to pay proper attention to the joints.

The Committee on Fences, Cattle Guards and Crossings recommended the use of high board fences at stations and in towns and large villages. They recommended a surface cattle guard as better than a pit, and thought the best one was made of ½-in. iron strips placed on edge and held in place by a frame.

The Committee on Wear of Locomotive Tires believed that the limit of wear should be ¼ in. from the standard. The Committee on Best Method of Securing Rails to the Ties thought there was no better method than to use good spikes. Rail braces were not recommended except on sharp curves, and tie-plates were thought advantageous on curves and with soft wood ties.

The attendance at the Convention was large, and there was a considerable number of exhibits of track material and appliances.

Roadmasters' Association of America.—The Ninth Annual Convention, which was held in Minneapolis, Minn., September 8–10, called out a large attendance, 120 members being present. There were 42 new members added to the Association, and the Secretary reported 489 members on the rolls.

At the meeting reports were presented by the Standing Committees. The Committee on Standard Frogs recommended for use on motion track a spring-rail frog for all rails 60 lbs. and over, and for yard use a rigid frog not less than 1 in 8. The report was accompanied by papers from Messrs. I. Burnett and W. H. Ellis.

The Committee on Track Joints reported progress, and appended statements of trials made of the Fisher, the McConway & Torley, the Long and the Weber joints. They also recommended the Heath and the Continuous joints to be added to the list of those on trial.

The Committee on Track Jacks made a report with recommendations, but declined to point out any particular jack for adoption.

The Committee on Track Work made a report recommending better division of sections and of the force employed, and indicating in what direction work should be applied.

On Tie Preservation the Committee gave an account of the different processes used, without making positive recommendations, but urged the selection of the best kinds of timber and greater attention to the time of cutting, to inspection and to seasoning before use. They also mentioned proper drainage and care in handling as means of prolonging life in ties.

The Committee on Interlocking Devices recommended the use of some system at all grade crossings, tunnel and drawbridge approaches and yards, and described the different systems which have been introduced.

All these reports were discussed at considerable length, and some valuable accounts of experience were drawn out by the discussions. There was also a discussion on the revision of the constitution, and the subject was finally referred to a committee. It was decided that the next meeting should be held partly in Chattanooga and partly in Atlanta.

The following officers were elected for the ensuing year: President, John Doyle, Detroit, Lansing & Northern Railroad; First Vice-President, W. A. Stearns, Chicago & Northwestern; Second Vice-President, J. B. Moll, Chicago, Milwaukee & St. Paul; Secretary and Treasurer, J. H. K. Burgwin, Grand Rapids & Indiana; Member of Executive Committee, O. F. Jordan, Michigan Central.

National Electric Light Association.—The Convention held in Montreal, September 7–11, was a very successful one, and we regret that space prevents us from giving a full report. There was a large attendance of electrical engineers from the United States and Canada, and the visitors were very handsomely entertained by the local Committee. Among the very important papers and discussions were those on Legislation, on Underground Currents, on Safe Wiring, on Central Stations, on Arc Light Carbons and on Rules for Wiring, but a number of other subjects were brought before the Convention.

The officers for the ensuing year are: President, C. R. Huntley, Buffalo, N. Y.; First Vice-President, James I. Ayer, St. Louis; Second Vice-President, M. J. Francisco, Rutland, Vt.; Secretary and Treasurer, John H. Beane, New York.

Association of State Geologists.—One of the results of the recent meeting of geologists in Washington was a resolution to form an association of Government and State geologists for the advancement of their work. The objects of this Association were defined as follows:

1. The determination of the proper objects of public geologic work.
2. The improvement of methods.
3. The unification of methods.
4. The establishment of the proper relative spheres and functions of National and State surveys.
5. Co-operation in works of common interest and the prevention of duplication of work.
6. The elevation of the standard of public geologic work and the sustenance of an appreciation of its value.
7. The inauguration of surveys by States not having such at present to co-operate with the other State surveys and with the National survey.

A committee was appointed, with Major J. W. Powell, of the United States Geological Survey as Chairman, to draw up a constitution, which is to be submitted to a meeting to be held in December next.

Master Car & Locomotive Painters' Association.—The Twenty-Second Annual Convention was held in Washington, beginning September 9, with a good attendance. The programme included a number of committee reports, and also questions for discussion, and it was generally carried out. The attendance at the meeting was large, and most of the reports were fully discussed.

The list of subjects, with the committees appointed to consider them, was as follows:

1. Is there a chemically pure soap that can be safely used for the purpose of cleaning the outside varnished surface of the railroad passenger-coach while in service? Stating soap, results and method of cleaning. William O. Quest, Pittsburgh & Lake Erie, Pittsburgh, Pa.; Thomas Bryne, Chesapeake & Ohio,

Richmond, Va.; J. H. Speer, Western Railroad of Alabama, Montgomery, Ala.

2. As a question of economy and durability, should rough-stuff be discarded on the outside surface of a railroad passenger-coach? If so, what materials and methods of application will best answer the requirements of this class of work, durability being the main consideration? W. T. Hogan, Atchison, Topeka & Santa Fé, Topeka, Kan.; A. R. Given, New York, West Shore & Buffalo, Frankfort, N. Y.; A. J. Bishop, Cleveland, Cincinnati, Chicago & St. Louis, Delaware, O.

3. According to the practical experience and ideas of railroad car and locomotive painters, can a new locomotive receive a durable finish in ten days? Stating method and materials used. A. J. Moriarty, Baltimore & Ohio, Newark, O.; A. S. Coleman, Intercolonial Railroad of Canada, Moncton, N. B.; J. H. Long, Chicago, Burlington & Quincy, Aurora, Ill.

4. "The cleaning of varnished surfaces of coaches, locomotives and other outside work while in service, material used, modes of application, etc."—Essay, by J. K. Lowry, Chicago, Burlington & Northern, La Crosse, Wis.

5. As an associated body, can we exert an influence on purchasing power that would remedy, where necessary, the quality of materials furnished?—an item of great importance when viewed from the standpoint that the best procurable is the most economical, as demonstrated through practical experience in the railroad paint-shop. James A. Gohen, Chesapeake & Ohio, Huntington, W. Va.; Robert McKeon, New York, Lake Erie & Western, Kent, O.; A. T. Schroeder, Chicago, Milwaukee & St. Paul, Milwaukee, Wis.

6. How should the new wood head-lining material of a passenger-coach be treated to prevent the finished surface from becoming destroyed, from decay of filler, grain raising, etc., due to the interior heat and moisture of a passenger-coach? J. T. McCracken, Delaware Car Works, Wilmington, Del.; Edward Webb, Laconia Car Works, Laconia, N. H.; Alexander Campbell, Manhattan Elevated, New York.

7. "Are railroad companies benefited through the Association of Master Car and Locomotive Painters?"—Essay by Samuel Brown, Old Colony, Boston, Mass.

8. Reports of committee of 12 appointed on geographical interchange of test panels, painted and exposed for a period of 10 months, in the extreme different climatic sections of the country.

The following queries were also submitted for general discussion:

1. Would it be advisable to form a Bureau of Information in connection with our Association?

2. Do you use all or part shellac on the hard-wood inside finish of your passenger-cars?

3. How do you prepare your stack blacking for locomotives while in service?

4. What materials do you use, and how long do you take, to paint your freight-cars?

5. As an item of shop economy, in what manner can you keep your paint stock and brushes in the most serviceable state?

6. What is the best formula for preparing floor paint for passenger-cars?

7. What are your views concerning the piece-work system for the railway paint-shop?

American Society of Civil Engineers.—At the first meeting of the season, held in New York, September 2, papers on Concrete Beams Reinforced by Twisted Iron for Floor Construction, by E. L. Barnes; on Longitudinal *versus* Cross Ties for Railroad Tracks, by E. E. R. Tratman; and on Transverse Breaking Strength of Plate Glass, by G. W. Plympton, were read and briefly discussed. Several written discussions on papers previously presented were also read.

At the regular meeting, September 16, a paper by George Y. Wisner, on the Brazos River Improvement, was read and discussed. A written discussion by Mr. Hutton, on Mr. Crowell's paper on Flood Protection at the Ravine du Sud, Haiti, was read and replied to by Mr. Crowell.

New England Railroad Club.—The first fall gathering of this Club took the form of an excursion to Crescent Park, R. I., with a clam-bake and other accompaniments. The excursion was over the Old Colony Road, and by steamer on the Narragansett Bay. A large number attended, and the excursion was much enjoyed.

Boston Society of Civil Engineers.—At the regular meeting, September 16, Edward G. Chamberlain, of Auburn, Mass., was elected a member.

President Stearns read a paper on Selection of Sources of Water Supply, which was discussed by members present. Mr. J. R. Freeman described and exhibited a device for testing pressure gauges.

Engineers' Club of Cincinnati.—At the regular meeting, August 20, one new member was elected.

A budget of short papers by various members, on the following subjects, was read: 1. Traveling Cranes; 2. The Width of Roadway in City Streets; 3. Settlement of Embankments; 4. Remarks on Water Feeding of Stationary Boilers; 5. Railroad Spirals; 6. Proposed Classification of Engineers; 7. State Inspection of Bridges.

The various papers excited considerable discussion, and the last one was referred to the Standing Committee on that subject.

Civil Engineers' Club of Cleveland.—At the regular monthly meeting, July 14, the report of the Club's delegate to the General Committee of Engineering Societies, Columbian Exposition, as printed and distributed, was taken up, and after some discussion the following resolution by Mr. J. L. Culley was unanimously adopted:

"*Resolved*, that this Club heartily indorse the action of the General Committee of Engineering Societies, Columbian Exposition, so far as the work has progressed, and that we are in full sympathy with the work as set forth in the report of our representatives."

The report of the Picnic Committee was presented by the Chairman, Mr. N. P. Bowler. The thanks of the Club were tendered to Mr. A. W. Johnston, Superintendent of the New York, Chicago & St. Louis Railroad, for his courtesy in providing free transportation facilities to the Club at its Annual Picnic on July 11.

Mr. James Ritchie read a paper describing a design for a built plate-girder to span a 60-ft. store front and carry the floors above of a heavily loaded building. The depth of the girder is the height of the second story, and it has openings in the web so that ordinary windows are not interfered with. The main difficulty is the transmission of shear on account of the web being interrupted by the window openings. This is overcome by forming the bottom flange partly of a 42-in. plate securely riveted at the pilasters so that the load concentrated there is transmitted through the rivets and the 42-in. plate as if the latter were the full depth of web.

In the absence of Mr. E. H. Jones, the Secretary read a paper by that gentleman on the recent Providence meeting of the American Society of Mechanical Engineers. It contained many interesting and instructive points from the papers read at that meeting.

Mr. C. P. Leland read a carefully prepared and highly interesting report upon the recent picnic of the Club.

Northwest Railroad Club.—At the first fall meeting, in St. Paul, September 15, the subjects for discussion were: 1. Painting Rolling Stock, with a paper by J. O. Pattee; 2. Fuel Economy and its Use, by P. H. Conradson. Both papers were discussed at considerable length.

Western Society of Engineers.—The first meeting of the Society for the season, on September 2, took the form of an excursion in which about 150 members joined. The day was devoted to the inspection of work upon the Columbian Exhibition buildings and grounds, a visit to the Pullman Works, the inspection of several new bridges in the neighborhood of Chicago, and the new system of intersecting tracks and signals at Sixteenth Street.

In the evening a business session was held, at which the principal topic was the selection of quarters for the Society for the ensuing year.

Master Mechanics' Association.—A circular from Secretary Sinclair announces the subjects for the next convention and the committees on the same as follows:

1. *Exhaust Pipes, Nozzles and Steam Passages.* Committee: C. F. Thomas, A. W. Gibbs, L. S. Randolph, J. M. Wallis, George W. Smith, Robert Quayle and John Y. Smith.

2. *Present Status of the Car Coupler Question.* Committee: John Hickey, Godfrey W. Rhodes, Sanford Keeler, R. H. Blackall and M. N. Forney.

3. *Standard Tests for Locomotives.* To investigate the practicability of establishing a standard system of tests to demonstrate the fuel and water consumption of locomotives; also to ascertain the value of the steam-engine indicator in locomotive tests. Committee: J. N. Lauder, J. Davis Barnett, Albert Griggs, John D. Campbell and F. W. Dean.

4. *Compound Locomotives.* To investigate the relative economy of compound and simple locomotives; also the most valu-

able form of compound locomotive. Committee: George Gibbs, William H. Lewis, Pulaski Leeds, James Meehan, T. W. Gentry and A. T. Woods. Auxiliary Committee: S. M. Vauclain, Baldwin Locomotive Works; Reuben Wells, Rogers Locomotive Works; H. N. Sprague, Porter Locomotive Works; A. J. Pitkin, Schenectady Locomotive Works; Joseph Lythgoe, Rhode Island Locomotive Works; F. J. Leigh, Canadian Locomotive Works, and D. A. Wightman, Pittsburgh Locomotive Works.

5. *Tests of Steel and Iron.* To investigate the critical temperature of steel and iron; also any other questions relating to steel and iron that the committee may consider of value. Committee: William Smith, J. N. Barr, A. W. Quackenbush, P. H. Peck and D. L. Barnes.

6. *Uniform Locomotive Performance Sheets.* To report on the practicability of establishing a system for recording the performance of locomotives that will fairly represent the work done. Committee: George F. Wilson, J. S. McCrum, John Player, James McNaughton and John A. Hill.

7. *Standard Bolts and Nuts.* To report on the best taper for bolts, and the proper size of nuts, rough and finished. Also to report on accurate measuring gauges. Committee: William Swanston, William Garstang, T. W. Gentry, W. Lavery, A. Dolbeer and L. R. Pomeroy.

8. *Boilers for High-Pressure Locomotives.* Committee: J. M. Boon, H. D. Gordon, J. S. Graham, J. H. McConnell and W. H. Marshall.

9. *Air Brake Standards and Inspection and Care of Air Brakes.* Committee: R. C. Blackall, G. W. Stevens and David Clark.

10. *Subjects for Investigation.* Committee: J. Davis Barnett, George Gibbs and William Smith.

Master Car Builders' Association.—A circular from the Secretary, John W. Cloud, gives the result of the letter ballots ordered at the last Convention, as follows:

A. The proposed standard for lettering freight cars was rejected, failing to receive a two-thirds vote, although it had a majority of all the votes cast.

B. The system of joint inspection, form of joint inspection agreement, and rules governing joint inspection were rejected, also failing to receive a two-thirds vote, although they had a majority.

C. The form of report of defective cars was rejected, failing by only a few votes.

D. The joint inspection defect card was also rejected.

E. In the air-brake standards, the change in diameter of pins from $1\frac{1}{16}$ in. to $1\frac{3}{32}$ in. was adopted, receiving 530 votes out of 566 votes cast.

F. The resolution rescinding the adoption of the Fletcher lid as a standard was adopted by a vote of 417 to 149.

G. The proposed standard journal-box, bearing, wedge and lid for 60,000 lb. cars was adopted by a vote of 365 to 176.

H. The proposed lid for the old standard journal-box was adopted by a vote of 378 to 159.

The Executive Committee has arranged the following subjects, and committees to report upon them in June, 1892:

1. *Joint Inspection.* To prepare a supplementary set of interpretations and illustrations of the Rules of Interchange. A. M. Waitt, H. C. McCarty, F. D. Adams, William Garstang, Joseph Townsend, J. T. Chamberlain and D. W. Hunter.

2 *Air Brake and Signal Instructions.* To review the instructions proposed at last convention. E. W. Grieves, R. D. Wade and J. L. Greatsinger.

3. *Cast-Iron Wheels.* To investigate what improvements are being made in the manufacture of wheels, so as to secure greater uniformity in quality, in depth of chill and in distribution of metal for proper balance. George W. West, W. H. Thomas and John Player.

4. *Freight Car Truck Frames.* To report upon the relative advantages of swinging and rigid bolsters, and upon the Fox Pressed Steel Truck as compared with the prevalent forms of freight car trucks. G. F. Wilson, W. S. Morris and W. Z. Turreff.

5. *M. C. B. Automatic Coupler Standards and Limits.* To consider the standard measurements, and whether any additional or other measurements are desirable as standard, and to report upon proper limits of variation to be allowed from standard measurements. J. S. Lentz, C. A. Schroyer and J. M. Wallis.

6. *Steam Heating and Ventilation of Passenger Equipment Cars.* To report upon the general progress and the efficiency of different systems, and to present drawings for a proposed standard location of ends of train pipe, and a proposed standard connection in detail for a union between the hose and pipe, so that one style of coupling may be readily removed and another substituted in its place. J. N. Barr, J. C. Barber, W. H. Lewis, T. A. Bissell and J. W. Marden.

7. *Steel-Tired Car Wheels.* To report upon relative merits of solid cast and wrought centers, and of plate centers bolted to hubs and tires. R. E. Marshall, J. O. Pattee and C. H. Cory.

8. *Wheel Guarantee.* To consider the communication from the Wheel Manufacturers' Association, read at last convention, and to report with recommendations. J. J. Hennessey and Thomas Sutherland.

9. *Steel Plate and Malleable Iron in Car Construction.* To recommend a standard for stake pockets, and a method in detail for attaching to cars. Also to recommend standards for center plates, in detail, showing one for iron transoms and one for wooden transoms. Drawings and models to accompany the report. William Forsyth, John Mackenzie and E. D. Bronner.

10. *Standards of the Association.* To consider the standards already adopted by the Association, and recommend what measures are expedient to secure their general adoption and use. R. H. Soule, E. Chamberlain and William McWood.

11. *Metal for Brake Shoes.* G. W. Rhodes, E. B. Wall and George Gibbs.

NOTES AND NEWS.

A Gas-Fired Boiler.—A gas-fired steam boiler has been patented by J. Jackson, of Liverpool, England. One arrangement of this invention consists in combining a gas producer with a tube-filled horizontal cylindrical vessel. The producer, which is fixed at one end, is in the form of a vertical cylinder, and has a similar outer shell, the intervening space between being filled with water. The outer shell is connected with the tube-filled vessel by suitable conduits arranged to cause the proper circulation throughout the structure. The gas produced is led down through the water by a conduit and delivered into a combustion chamber, into which air suitably heated by passing

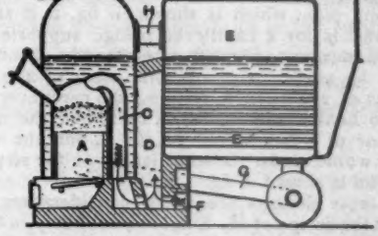


FIG. 1.

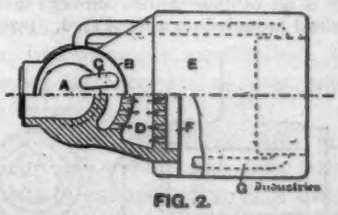


FIG. 2.

through brickwork channels is introduced. The accompanying illustrations show the invention, fig. 1 being a sectional elevation and fig. 2 a part sectional plan. The gas producer *A* has an outer shell, *B*, and conduit, *C*, leading into the combustion chamber *D*, from whence the gases pass through the tubes *E* of the cylindrical vessel. Air enters by passages *F*. *G G* are the conduits for the water, and *H* is a pipe above the water-line. Claims: The combination, in a horizontal steam generator, of a gas-producer furnace set within a shell and surrounded by water, the gas produced therein being conveyed by suitable conduits from the producer furnace and directly burned by air suitably introduced, and the gases of combustion passing over surfaces of the steam generator to be heated.—*Industries.*

Coal in Belgium.—The total amount of coal mined in Belgium last year was 20,565,960 tons, an increase of 5 per cent. over the preceding year. The number of persons employed in and about the mines was 116,779. The amount paid for wages averaged $1.20 per ton of coal mined, and was about 45 per

cent. of the selling price. The price of coal was higher than for several years past.

Designs for a High Level Bridge.—The city of Lyons, in France, is situated in a narrow valley, through the center of which flows the river Saone. On either side is a high hill or bluff, and it has been for a long time considered desirable to connect these hills by a bridge, but the width and depth of the valley is so great that until recently it has been impossible to do so. At the point where the bridge could be most conveniently built the hills are about 1,700 ft. apart and about 300 ft. in height above the river.

Two plans have been submitted for this bridge. Fig. 1 shows a bridge or viaduct proposed by M. Clavenad, the Director of Public Works of the city of Lyons. His plan provides for a viaduct to be carried on five iron piers and on a central arch composed of steel girders. The general plan is based on that of the great bridge over the Douro at Lisbon. On this plan the

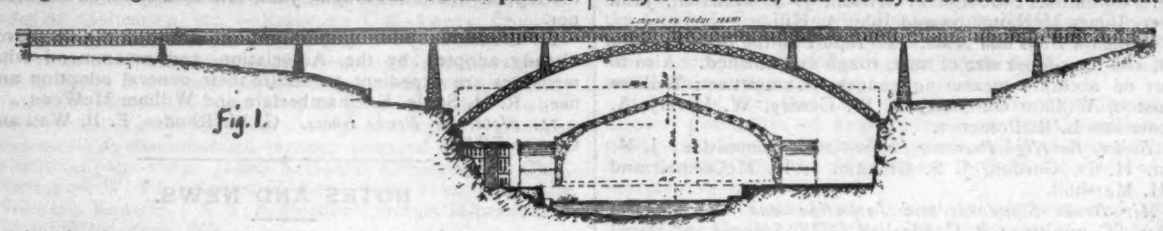


Fig. 1.

Fig. 2.

total length of the viaduct would be 1,850 ft., and the central arch would have a span of 700 ft. An outline of this plan is shown in fig. 1, which is taken from *Le Genie Civil*.

The second plan, which is shown in fig. 2, is submitted by M. Eiffel, and is for a cantilever bridge supported on stone piers, with a masonry approach at each end. On this plan the bridge will be made up of a central span of 466 ft. and two lateral spans of 279 ft. each, forming the cantilever part of the bridge; two bank spans of 207 ft. each, and the masonry approaches, one of which would be 164 ft. and the other 295 ft. long. This would make the total length of the structure 1,690 ft. This plan is shown in fig. 2.

Both of these designs are under consideration; but it is thought that the design of M. Eiffel is most likely to be accepted.

Oiling Fixed Studs.—A writer in *Industry*, published in San Francisco, says: "If there is anything ridiculous in common practice, it is an oil-hole drilled through the hub or boss of a pulley or wheel mounted on a fixed stud. Just how a bearing of this kind is to be oiled in that way nobody can tell, and why the oil-hole is not made in the stud itself would be a difficult problem.

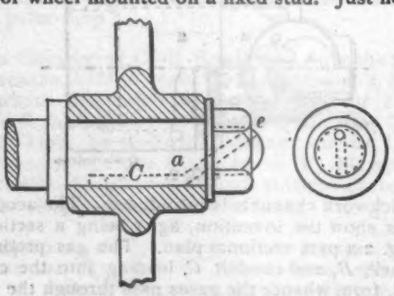


FIG. 1.

"The engraving, fig 1, shows how an oil-way should be made for a stud, as common sense will suggest. The job is still better if there is a groove cut in the bottom of the stud and some packing laid in, as shown at *C*. The best thing is a strip of felt cut from the sheet."

Steel Chimneys.—Steel chimneys are being erected in connection with some of Chicago's tall buildings. The Fair building has at present the tallest under construction. The chimney, when completed, will be 250 ft. high, being considerably higher than any other in the city, the highest at the present time being the one at the Gottfried Brewing Company's plant at Archer and Stewart avenues, which is 175 ft. The outside diameter is 9 ft. 5 in., while the steel varies in thickness from $\frac{5}{16}$ in. at the top to $\frac{1}{2}$ in. at the bottom. The lower 75 ft. of the chimney is lined with fire brick 8 in. deep, formed to fit the shell compactly all around. Above this it is lined with hollow tile. This lining is supported at intervals of 25 ft. by angle iron riveted to the steel shell; in other words, the chimney is lined in a manner similar to blast furnaces and foundry cupolas, and no expansion by heat can lessen its strength. The joints are all hot riveted. The steel shell is carefully protected from corrosion and from any attacks by the weather by painting inside and out. The weight of the chimney is spread to the foundations in the same general way as that of the columns of the building, the base or foundation on which it rests being constructed in the same manner. The ground is first covered with a layer of cement, then two layers of steel rails in cement and one layer of I-beams, on which the cast-iron shoe which takes the shell of the stack rests. The capacity of the chimney is twelve 60 in. boilers 20 ft. in length.

This is the first time this material has been used in the construction of the chimneys of mercantile buildings. The magnitude of the building and the necessity of economizing in space, the foundations for the columns occupying about all the ground, led the architects to adopt steel as the material for this purpose. Brick has been used almost entirely heretofore, but upon investigation it was found that the weight of a brick chimney of this size would be almost 700 tons, while of steel construction it would weigh, including the linings, a little less than 250. The outside diameter of the present chimney is 9 ft. 5 in., while were it constructed of brick it would be 16 ft. 6 in., thus making a great saving in space. Another consideration was the time consumed in construction. A brick chimney of this height, 250 ft. above the sidewalk, should not be built faster than 2½ ft. a day on account of the settlement and the setting of the mortar, while of steel it can be erected at the rate of 20 ft. a day. Another important consideration is that it costs only about 60 per cent. of what a brick chimney would cost..—*Iron Age*.

Compensating a Grade.—The track of the Rainier Avenue Electric Railroad has been completed down Washington Street as far as Third, and cars are now regularly running to Eighth. The compensation weights for taking the cars up the steep incline between Fifth and Eighth streets are in place. Upon trial the contrivance has worked successfully, and cars will be running up and down in a few days.

The arrangement is a very ingenious one. The regular track is standard gauge; inside of it and 2 or 3 ft. below the street level is a second track of 2-ft. gauge. On this runs a truck loaded with lead so as to weigh beween 5 and 6 tons. This lower track is covered over, and nothing of it is seen from the street. When the truck is at the bottom of the hill a cable to which it is attached runs on pulleys to the top, and there turns over a big concealed wheel out to the side of the track.

A car coming down the hill takes the end of the cable, and the weight of the descending car, together with the electric power, draws the heavy truck underneath up the 16½ per cent. grade to the top of the hill. When the car returns the truck is at the top of the hill. As soon as the car is attached to the end of the cable, then at the bottom, the truck is released, and its weight as it runs down draws the car up. The cable pulled out at the top of the hill as the car comes down runs in a narrow slot just inside of the track on the north side of the street. —*Seattle, Wash., Post-Intelligencer*.